

# EXHIBIT O

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**Nesbitt et al.**

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(54) **MULTI-LAYER GOLF BALL**

(58) **Field of Search** ..... 473/371, 372,  
473/377, 378, 376

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**U.S. PATENT DOCUMENTS**  
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3,756,607    9/1973   Lukinac et al. .  
4,431,193   \* 2/1984   Nesbitt ..... 473/378  
4,683,257   \* 7/1987   Kakiuchi et al. .... 525/432  
4,984,804   \* 1/1991   Yamada et al. .... 473/378  
5,068,151   11/1991   Nakamura .  
5,387,637   2/1995   Sullivan .  
\* cited by examiner

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(\*) **Notice:**    Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(52) **Primary Examiner**—Mark S. Graham  
**Assistant Examiner**—Raeann Gordon

**Related U.S. Application Data**

(63) Continuation-in-part of application No. 08/815,556, filed on Mar. 12, 1997, which is a continuation of application No. 08/562,540, filed on Nov. 20, 1995, now abandoned, which is a continuation of application No. 08/070,510, filed on Jun. 1, 1993, now abandoned.

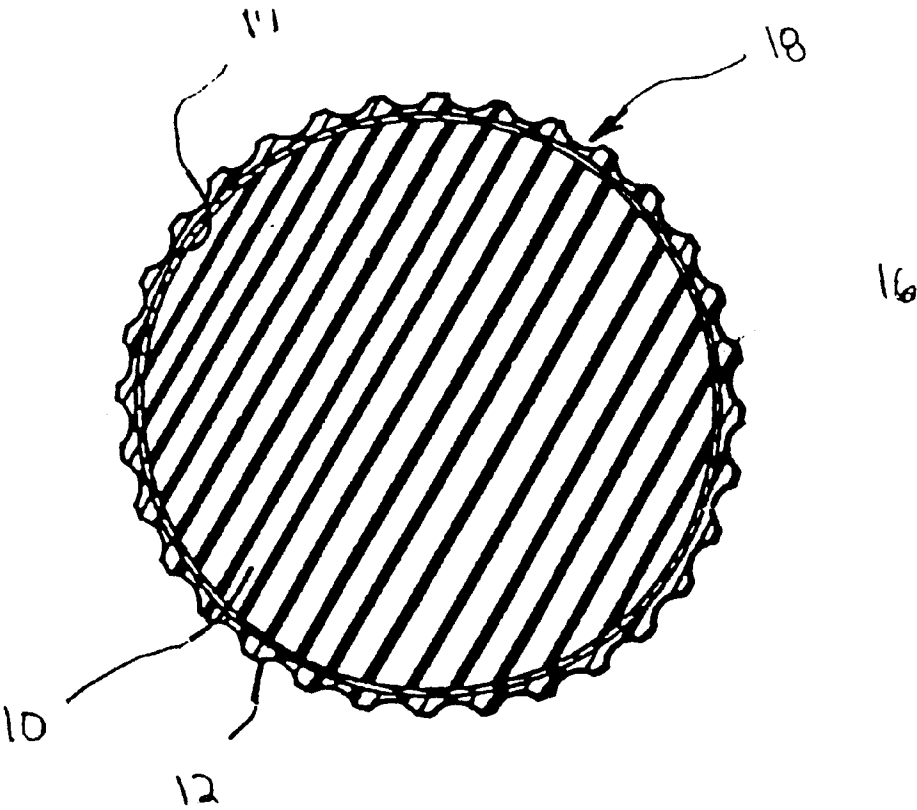
(60) Provisional application No. 60/116,846, filed on Jan. 22, 1999, provisional application No. 60/117,328, filed on Jan. 22, 1999, provisional application No. 60/116,901, filed on Jan. 22, 1999, provisional application No. 60/116,899, filed on Jan. 22, 1999, and provisional application No. 60/116,870, filed on Jan. 22, 1999.

(51) **Int. Cl.**<sup>7</sup> ..... **A63B 37/06**

(52) **U.S. Cl.** ..... **473/377; 524/432**

(57) **ABSTRACT**  
The present invention is directed to an improved multi-layer golf ball comprising a core, an inner cover layer and an outer cover layer. The inner cover layer is comprised of a high acid ionomer or ionomer blend which may or may not include a filler such as zinc-stearate. The outer cover layer is comprised of a soft, very low modulus ionomer or ionomer blend, or a non-ionomeric thermoplastic elastomer such as polyurethane, polyester or polyesteramide. The resulting multi-layered golf ball of the present invention provides for enhanced distance without sacrificing playability or durability when compared to known multi-layer golf balls.

**21 Claims, 1 Drawing Sheet**



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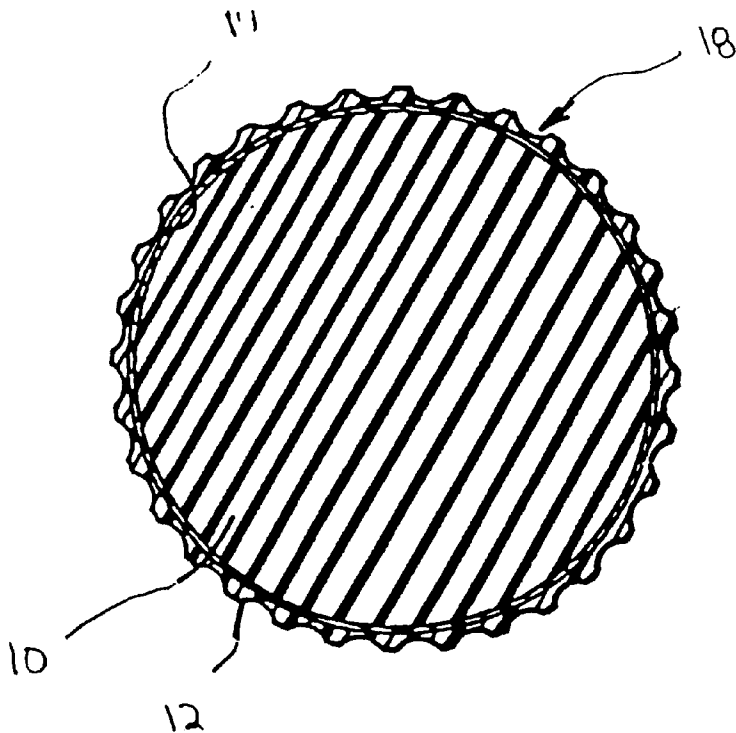


FIG. 1

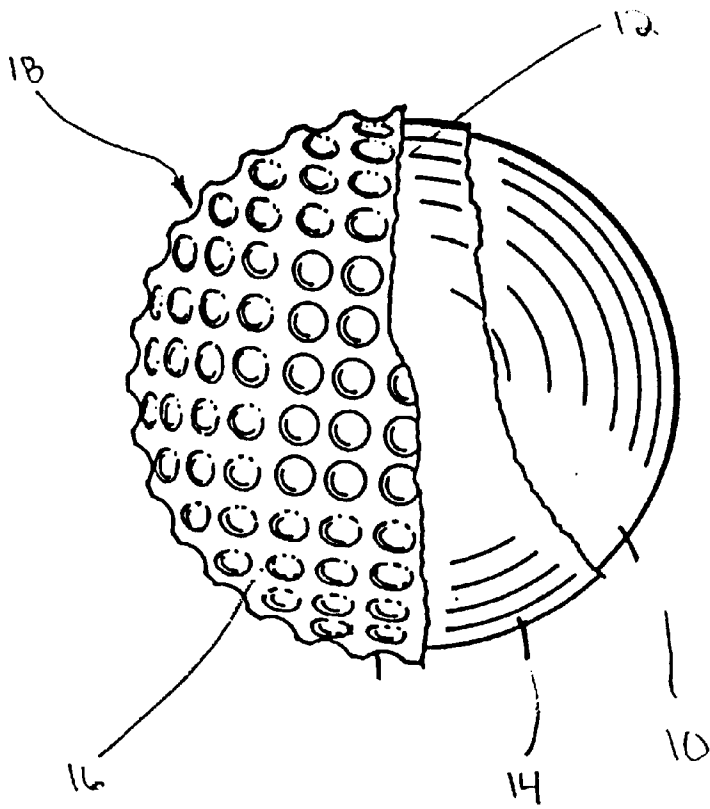


FIG. 2

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**MULTI-LAYER GOLF BALL**

This application claims the benefit of the filing date of U.S. Provisional Applications: No. 60/116, 846, filed Jan. 22, 1999; No. 60/117,328, filed Jan. 22, 1999; No. 60/116, 901, filed Jan. 22, 1999; No. 60/116,899, filed Jan. 22, 1999; and No. 60/116,870, filed Jan. 22, 1999. In addition, this application is a continuation-in-part of U.S. application Ser. No.08/815,556, filed Mar. 12,1997, which is a continuation of U.S. application Ser. No. 08/562,540 filed on Nov. 20, 1995 (abandoned), which is a continuation of U.S. application Serial No. 08/070,510, filed on Jun. 1, 1993 (abandoned).

**FIELD OF THE INVENTION**

The present invention relates to golf balls and, more particularly, to improved golf balls comprising multi-layer covers which have a hard inner layer and a relatively soft outer layer. The improved multi-layer golf balls provide for enhanced distance and durability properties while at the same time offering the "feel" and spin characteristics associated with soft balata and balata-like covers of the prior art. In addition, the present invention is also directed to golf balls utilizing improved polybutadiene compositions for use in molded golf ball cores in conjunction with the particular cover compositions.

**BACKGROUND OF THE INVENTION**

Traditional golf ball covers have been comprised of balata or blends of balata with elastomeric or plastic materials. The traditional balata covers are relatively soft and flexible. Upon impact, the soft balata covers compress against the surface of the club producing high spin. Consequently, the soft and flexible balata covers provide an experienced golfer with the ability to apply a spin to control the ball in flight in order to produce a draw or a fade, or a backspin which causes the ball to "bite" or stop abruptly on contact with the green. Moreover, the soft balata covers produce a soft "feel" to the low handicap player. Such playability properties (workability, feel, etc.) are particularly important in short iron play with low swing speeds and are exploited significantly by relatively skilled players.

Despite all the benefits of balata, balata covered golf balls are easily cut and/or damaged if mis-hit. Golf balls produced with balata or balata-containing cover compositions therefore have a relatively short lifespan.

As a result of this negative property, balata and its synthetic substitutes, trans-polybutadiene and transpolyisoprene, have been essentially replaced as the cover materials of choice by new cover materials comprising ionomeric resins.

Ionomeric resins are polymers containing interchain ionic bonding. As a result of their toughness, durability and flight characteristics, various ionomeric resins sold by E. I. DuPont de Nemours & Company under the trademark "Surlyn®" and more recently, by the Exxon Corporation (see U. S. Pat. No. 4,911,451) under the trademarks "Escor®" and the trade name "Iotek", have become the materials of choice for the construction of golf ball covers over the traditional "balata" (transpolyisoprene, natural or synthetic) rubbers. As stated, the softer balata covers, although exhibiting enhanced playability properties, lack the durability (cut and abrasion resistance, fatigue endurance, etc.) properties required for repetitive play.

Ionomeric resins are generally ionic copolymers of an olefin, such as ethylene, and a metal salt of an unsaturated

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carboxylic acid, such as acrylic acid, methacrylic acid, or maleic acid. Metal ions, such as sodium or zinc, are used to neutralize some portion of the acidic group in the copolymer resulting in a thermoplastic elastomer exhibiting enhanced properties, i.e. durability, etc., for golf ball cover construction over balata. However, some of the advantages gained in increased durability have been offset to some degree by the decreases produced in playability. This is because although the ionomeric resins are very durable, they tend to be very hard when utilized for golf ball cover construction, and thus lack the degree of softness required to impart the spin necessary to control the ball in flight. Since the ionomeric resins are harder than balata, the ionomeric resin covers do not compress as much against the face of the club upon impact, thereby producing less spin. In addition, the harder and more durable ionomeric resins lack the "feel" characteristic associated with the softer balata related covers.

As a result, while there are currently more than fifty (50) commercial grades of ionomers available both from DuPont and Exxon, with a wide range of properties which vary according to the type and amount of metal cations, molecular weight, composition of the base resin (i.e., relative content of ethylene and methacrylic and/or acrylic acid groups) and additive ingredients such as reinforcement agents, etc., a great deal of research continues in order to develop a golf ball cover composition exhibiting not only the improved impact resistance and carrying distance properties produced by the "hard" ionomeric resins, but also the playability (i.e., "spin", "feel", etc.) characteristics previously associated with the "soft" balata covers, properties which are still desired by the more skilled golfer.

Consequently, a number of two-piece (a solid resilient center or core with a molded cover) and three-piece (a liquid or solid center, elastomeric winding about the center, and a molded cover) golf balls have been produced by the present inventor and others to address these needs. The different types of materials utilized to formulate the cores, covers, etc. of these balls dramatically alters the balls' overall characteristics. In addition, multi-layered covers containing one or more ionomer resins have also been formulated in an attempt to produce a golf ball having the overall distance, playability and durability characteristics desired.

This was addressed by Spalding & Evenflo Companies, Inc., the assignee of the present invention, in U. S. Pat. No. 4,431,193 where a multi-layered golf ball is disclosed. In the '193 patent, a multi-layer golf ball is produced by initially molding a first cover layer on a spherical core and then adding a second layer. The first layer is comprised of a hard, high flexural modulus resinous material such as type 1605 Surlyn® (now designated Surlyn® 8940). Type 1605 Surlyn® (Surlyn® 8940) is a sodium ion based low acid (less than or equal to 15 weight percent methacrylic acid) ionomer resin having a flexural modulus of about 51,000 psi. An outer layer of a comparatively soft, low flexural modulus resinous material such as type 1855 Surlyn® (now designated Surlyn® 9020) is molded over the inner cover layer. Type 1855 Surlyn® (Surlyn® 9020) is a zinc ion based low acid (10 weight percent methacrylic acid) ionomer resin having a flexural modulus of about 14,000 psi.

The '193 patent teaches that the hard, high flexural modulus resin which comprises the first layer provides for a gain in coefficient of restitution over the coefficient of restitution of the core. The increase in the coefficient of restitution provides a ball which serves to attain or approach the maximum initial velocity limit of 255 feet per second as provided by the United States Golf Association (U.S.G.A.) rules. The relatively soft, low flexural modulus outer layer

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provides essentially no gain in the coefficient of restitution but provides for the advantageous "feel" and playing characteristics of a balata covered golf ball. Unfortunately, however, while a ball of the '193 patent does exhibit enhanced playability characteristics with improved distance (i.e. enhanced C.O.R. values) over a number of other known multi-layered balls, the ball suffers from poor cut resistance and relatively short distance (i.e. lower C.O.R. values) when compared to two-piece, single cover layer balls. These undesirable properties make the ball produced in accordance with the '193 patent unacceptable by today's standards.

With respect to cores of golf balls, polybutadiene has been utilized in forming golf ball cores. Prior artisans have investigated utilizing various grades of polybutadiene in core compositions. For example, such attempts are described in U.S. Pat. Nos. 5,385,440; 4,931,376; 4,683,257; 4,955,613; and 4,984,803; and in Japanese Patent References JP 58225138 and JP 7268132, all of which are hereby incorporated by reference. Although some of the core compositions described in these disclosures are satisfactory, a need remains for an improved composition for forming golf ball cores.

The present invention is directed to new multi-layer golf ball compositions which provide for enhanced coefficient of restitution (i.e. enhanced resilience or carrying distance) and/or durability properties when compared to the multi-layer balls found in the prior art, as well as improved outer cover layer softness and durability. As such, the playability characteristics (i.e., "feel", "click", "spin", etc.) are not diminished.

In addition, it is also an object of the present invention to provide an improved polybutadiene composition which, when utilized to formulate golf ball cores in combination with the multi-layer covers disclosed herein, produces golf balls exhibiting enhanced C.O.R. without increasing hardness. An additional object of the invention is to produce a golf ball core from a polybutadiene composition having a high Mooney viscosity and/or a high molecular weight and low dispersity.

These and other objects and features of the invention will be apparent from the following summary and description of the invention, the drawings and from the claims.

### SUMMARY OF THE INVENTION

The present invention is directed to improved multi-layer golf ball cover compositions and the resulting multi-layer golf balls produced using the improved compositions. The novel multi-layer golf ball covers of the present invention include a first or inner layer or ply of a high acid (greater than 16 weight percent acid) ionomer or ionomer blend and second or outer layer or ply comprised of a comparatively softer, low modulus ionomer, ionomer blend or other non-ionomeric thermoplastic elastomer such as polyurethane, a polyester elastomer such as Hytrel® polyester elastomer of E. I. DuPont de Nemours & Company, or a polyesteramide such as the Elf Atochem S.A. Pebax® polyesteramide. Preferably, the outer cover layer includes a blend of hard and soft low acid (i.e. 16 weight percent acid or less) ionomers.

It has been found that the recently developed high acid ionomer based inner layer, provides for a substantial increase in resilience (i.e., enhanced distance) over known multi-layer covered balls. The softer outer layer provides for desirable "feel" and high spin rate while maintaining respectable resiliency. The soft outer layer allows the cover to deform more during impact and increases the area of contact between the club face and the cover, thereby impart-

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ing more spin on the ball. As a result, the soft cover provides the ball with a balata-like feel and playability characteristics with improved distance and durability. Consequently, the overall combination of the inner and outer cover layers results in a golf ball having enhanced resilience (improved travel distance) and durability (i.e. cut resistance, etc.) characteristics while maintaining and in many instances, improving the balls playability properties.

The combination of a high acid ionomer or ionomer blend inner cover layer with a soft, relatively low modulus ionomer, ionomer blend or other non-ionomeric thermoplastic elastomer outer cover layer provides for excellent overall coefficient of restitution (i.e., excellent resilience) because of the improved resiliency produced by the inner cover layer. While some improvement in resiliency is also produced by the outer cover layer, the outer cover layer generally provides for a more desirable feel and high spin, particularly at lower swing speeds with highly lofted clubs such as half wedge shots.

Two principal properties involved in golf ball performance are resilience and hardness. Resilience is determined by the coefficient of restitution (C.O.R.), the constant "e" which is the ratio of the relative velocity of two elastic spheres after direct impact to that before impact. As a result, the coefficient of restitution ("e") can vary from 0 to 1, with 1 being equivalent to an elastic collision and 0 being equivalent to an inelastic collision.

Resilience (C.O.R.), along with additional factors such as club head speed, angle of trajectory and ball configuration (i.e., dimple pattern) generally determine the distance a ball will travel when hit. Since club head speed and the angle of trajectory are factors not easily controllable by a manufacturer, factors of concern among manufacturers are the coefficient of restitution (C.O.R.) and the surface configuration of the ball.

The coefficient of restitution (C.O.R.) in solid core balls is a function of the composition of the molded core and of the cover. In balls containing a wound core (i.e., balls comprising a liquid or solid center, elastic windings, and a cover), the coefficient of restitution is a function of not only the composition of the center and cover, but also the composition and tension of the elastomeric windings. Although both the core and the cover contribute to the coefficient of restitution, the present invention is directed to the enhanced coefficient of restitution (and thus travel distance) which is affected by the cover composition.

In this regard, the coefficient of restitution of a golf ball is generally measured by propelling a ball at a given speed against a hard surface and measuring the ball's incoming and outgoing velocity electronically. As mentioned above, the coefficient of restitution is the ratio of the outgoing velocity to the incoming velocity. The coefficient of restitution must be carefully controlled in all commercial golf balls in order for the ball to be within the specifications regulated by the United States Golf Association (U.S.G.A.). Along this line, the U.S.G.A. standards indicate that a "regulation" ball cannot have an initial velocity (i.e., the speed off the club) exceeding 255 feet per second. Since the coefficient of restitution of a ball is related to the ball's initial velocity, it is highly desirable to produce a ball having sufficiently high coefficient of restitution to closely approach the U.S.G.A. limit on initial velocity, while having an ample degree of softness (i.e., hardness) to produce enhanced playability (i.e., spin, etc.).

The hardness of the ball is the second principal property involved in the performance of a golf ball. The hardness of

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the ball can affect the playability of the ball on striking and the sound or "click" produced. Hardness is determined by the deformation (i.e., compression) of the ball under various load conditions applied across the ball's diameter (i.e., the lower the compression value, the harder the material). As indicated in U.S. Pat. No. 4,674,751, softer covers permit the accomplished golfer to impart proper spin. This is because the softer covers deform on impact significantly more than balls having "harder" ionomeric resin covers. As a result, the better player is allowed to impart fade, draw or backspin to the ball thereby enhancing playability. Such properties may be determined by various spin rate tests such as the "nine iron" spin rate test described below in the Examples.

Accordingly, the present invention is directed to an improved multi-layer cover which produces, upon molding each layer around a core (preferably a solid core) to formulate a multi-layer cover, a golf ball exhibiting enhanced distance (i.e., resilience) without adversely affecting, and in many instances, improving the ball's playability (hardness/softness) and/or durability (i.e., cut resistance, fatigue resistance, etc.) characteristics.

Additionally, the present invention is also directed to a golf ball comprising a core that includes a particular combination of polybutadiene rubbers, and a cover disposed about the core which includes a specific combination of ionomer resins. The polybutadiene rubbers used in the particular combination include a first polybutadiene rubber that is obtained utilizing a cobalt catalyst and which exhibits a Mooney viscosity in the range of from about 70 to about 83. The combination of polybutadiene rubbers also includes a second polybutadiene rubber that is obtained utilizing a neodymium series catalyst and which exhibits a Mooney viscosity of from about 30 to about 70.

These and other objects and features of the invention will be apparent from the following detailed description.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross-sectional view of a golf ball embodying the invention illustrating a core 10 and a cover 12 consisting of an inner layer 14 and an outer layer 16 having dimples 18; and

FIG. 2 is a diametrical cross-sectional view of a golf ball of the invention having a core 10 and a cover 12 made of an inner layer 14 and an outer layer 16 having dimple 18.

#### DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to improved multi-layer golf balls, particularly a golf ball comprising a multi-layered cover 12 over a solid core 10, and method for making same.

The multi-layered cover 12 comprises two layers: a first or inner layer or ply 14 and a second or outer layer or ply 16. The inner layer 14 is comprised of a high acid (i.e. greater than 16 weight percent acid) ionomer resin or high acid ionomer blend. Preferably, the inner layer is comprised of a blend of two or more high acid (i.e. at least 16 weight percent acid) ionomer resin neutralized to various extents by different metal cations. The inner cover layer may or may not include a metal stearate (e.g., zinc stearate) or other metal fatty acid salt. The purpose of the metal stearate or other metal fatty acid salt is to lower the cost of production without affecting the overall performance of the finished golf ball.

The inner layer compositions include the high acid ionomers such as those recently developed by E. I. DuPont de

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Nemours & Company under the trademark "Surlyn" and by Exxon Corporation under the trademark "Escor®" or trade-name "Iotek", or blends thereof. Examples of compositions which may be used as the inner layer herein are set forth in detail in copending U. S. Ser. No. 07/776,803 filed Oct. 15, 1991, and Ser. No. 07/901,660 filed Jun. 19, 1992, both incorporated herein by reference. Of course, the inner layer high acid ionomer compositions are not limited in any way to those compositions set forth in said copending applications. For example, the high acid ionomer resins recently developed by Spalding & Evenflo Companies, Inc., the assignee of the present invention, and disclosed in U.S. Ser. No. 07/901,680, filed Jun. 19, 1992, incorporated herein by reference, may also be utilized to produce the inner layer of the multi-layer cover used in the present invention.

The high acid ionomers which may be suitable for use in formulating the inner layer compositions of the subject invention are ionic copolymers which are the metal, i.e., sodium, zinc, magnesium, etc., salts of the reaction product of an olefin having from about 2 to 8 carbon atoms and an unsaturated monocarboxylic acid having from about 3 to 8 carbon atoms. Preferably, the ionomeric resins are copolymers of ethylene and either acrylic or methacrylic acid. In some circumstances, an additional comonomer such as an acrylate ester (i.e., iso- or n-butylacrylate, etc.) can also be included to produce a softer terpolymer. The carboxylic acid groups of the copolymer are partially neutralized (i.e., approximately 10–75%, preferably 30–70%) by the metal ions. Each of the high acid ionomer resins which may be included in the inner layer cover compositions of the invention contains greater than about 16% by weight of a carboxylic acid, preferably from about 17% to about 25% by weight of a carboxylic acid, more preferably from about 18.5% to about 21.5% by weight of a carboxylic acid.

Although the inner layer cover composition preferably includes a high acid ionomeric resin and the scope of the patent embraces all known high acid ionomeric resins falling within the parameters set forth above, only a relatively limited number of these high acid ionomeric resins have recently become commercially available.

The high acid ionomeric resins available from Exxon under the designation "Escor®" and or "Iotek", are somewhat similar to the high acid ionomeric resins available under the "Surlyn®" trademark. However, since the Escor®/Iotek ionomeric resins are sodium or zinc salts of poly(ethylene-acrylic acid) and the "Surlyn®" resins are zinc, sodium, magnesium, etc. salts of poly(ethylene-methacrylic acid), distinct differences in properties exist.

Examples of the high acid methacrylic acid based ionomers found suitable for use in accordance with this invention include Surlyn® AD-8422 (sodium cation), Surlyn® 8162 (zinc cation), Surlyn® SEP-503-1 (zinc cation), and Surlyn® SEP-503-2 (magnesium cation). According to DuPont, all of these ionomers contain from about 18.5 to about 21.5% by weight methacrylic acid.

More particularly, Surlyn® AD-8422 is currently commercially available from DuPont in a number of different grades (i.e., AD-8422-2, AD-8422-3, AD-8422-5, etc.) based upon differences in melt index. According to DuPont, Surlyn® AD-8422 offers the following general properties when compared to Surlyn®8920, the stiffest, hardest of all on the low acid grades (referred to as "hard" ionomers in U.S. Pat. No. 4,884,814):

	LOW ACID (15 wt % Acid)			HIGH ACID (≥20 wt% Acid)		
	SURLYN®			SURLYN®		
	8920			8422-2		
IONOMER						
Cation	Na			Na		
Melt Index	1.2			2.8		
Sodium, Wt %	2.3			1.9		
Base Resin MI	60			60		
MP <sup>1</sup> , ° C.	88			86		
FP <sup>1</sup> , ° C.	47			48.5		
COMPRESSION MOLDING <sup>2</sup>						
Tensile Break, psi	4350			4190		
Yield, psi	2880			3670		
Elongation, %	315			263		
Flex Mod, K psi	53.2			76.4		
Shore D hardness	66			67		

<sup>1</sup>DSC second heat, 10° C./min heating rate.  
<sup>2</sup>Samples compression molded at 150° C. annealed 24 hours at 60° C. 8422-2, -3 were homogenized at 190° C. before molding.

In comparing Surlyn® 8920 to Surlyn® 8422-2 and Surlyn® 8422-3, it is noted that the high acid Surlyn® 8422-2 and 8422-3 ionomers have a higher tensile yield, lower elongation, slightly higher Shore D hardness and much higher flexural modulus. Surlyn® 8920 contains 15 weight percent methacrylic acid and is 59% neutralized with sodium.

In addition, Surlyn® SEP-503-1 (zinc cation) and Surlyn® SEP-503-2 (magnesium cation) are high acid zinc and magnesium versions of the Surlyn® AD 8422 high acid ionomers. When compared to the Surlyn® AD 8422 high acid ionomers, the Surlyn SEP-503-1 and SEP-503-2 ionomers can be defined as follows:

Surlyn® Ionomer	Ion	Melt Index	Neutralization %
AD 8422-3	Na	1.0	45
SEP 503-1	Zn	0.8	38
SEP 503-2	Mg	1.8	43

Furthermore, Surlyn® 8162 is a zinc cation ionomer resin containing approximately 20% by weight (i.e. 18.5–21.5% weight) methacrylic acid copolymer that has been 30–70% neutralized. Surlyn® 8162 is currently commercially available from DuPont.

Examples of the high acid acrylic acid based ionomers suitable for use in the present invention also include the Escor® or lotek high acid ethylene acrylic acid ionomers produced by Exxon. In this regard, Escor® or lotek 959 is a sodium ion neutralized ethylene-acrylic neutralized ethylene-acrylic acid copolymer. According to Exxon, loteks 959 and 960 contain from about 19.0 to about 21.0% by weight acrylic acid with approximately 30 to about 70 percent of the acid groups neutralized with sodium and zinc ions, respectively. The physical properties of these high acid acrylic acid based ionomers are as follows:

PROPERTY	ESCOR® (IOTEK) 959	ESCOR® (IOTEK) 960
Melt Index, g/10 min	2.0	1.8
Cation	Sodium	Zinc
Melting Point, ° F.	172	174
Vicat Softening Point, ° F.	130	131
Tensile @ Break, psi	4600	3500
Elongation @ Break, %	325	430
Hardness, Shore D	66	57
Flexural Modulus, psi	66,000	27,000

Furthermore, as a result of the development by the inventor of a number of new high acid ionomers neutralized to various extents by several different types of metal cations, such as by manganese, lithium, potassium, calcium and nickel cations, several new high acid ionomers and/or high acid ionomer blends besides sodium, zinc and magnesium high acid ionomers or ionomer blends are now available for golf ball cover production. It has been found that these new cation neutralized high acid ionomer blends produce inner cover layer compositions exhibiting enhanced hardness and resilience due to synergies which occur during processing. Consequently, the metal cation neutralized high acid ionomer resins recently produced can be blended to produce substantially harder inner cover layers for multi-layered golf balls having higher C.O.R.'s than those produced by the low acid ionomer inner cover compositions presently commercially available.

More particularly, several new metal cation neutralized high acid ionomer resins have been produced by the inventor by neutralizing, to various extents, high acid copolymers of an alpha-olefin and an alpha, beta-unsaturated carboxylic acid with a wide variety of different metal cation salts. This discovery is the subject matter of U.S. application Ser. No. 901,680, incorporated herein by reference. It has been found that numerous new metal cation neutralized high acid ionomer resins can be obtained by reacting a high acid copolymer (i.e. a copolymer containing greater than 16% by weight acid, preferably from about 17 to about 25 weight percent acid, and more preferably about 20 weight percent acid), with a metal cation salt capable of ionizing or neutralizing the copolymer to the extent desired (i.e. from about 10% to 90%).

The base copolymer is made up of greater than 16% by weight of an alpha, beta-unsaturated carboxylic acid and an alpha-olefin. Optionally, a softening comonomer can be included in the copolymer. Generally, the alpha-olefin has from 2 to 10 carbon atoms and is preferably ethylene, and the unsaturated carboxylic acid is a carboxylic acid having from about 3 to 8 carbons. Examples of such acids include acrylic acid, methacrylic acid, ethacrylic acid, chloroacrylic acid, crotonic acid, maleic acid, fumaric acid, and itaconic acid, with acrylic acid being preferred.

The softening comonomer that can be optionally included in the invention may be selected from the group consisting of vinyl esters of aliphatic carboxylic acids wherein the acids have 2 to 10 carbon atoms, vinyl ethers wherein the alkyl groups contains 1 to 10 carbon atoms, and alkyl acrylates or methacrylates wherein the alkyl group contains 1 to 10 carbon atoms. Suitable softening comonomers include vinyl acetate, methyl acrylate, methyl methacrylate, ethyl acrylate, ethyl methacrylate, butyl acrylate, butyl methacrylate, or the like.

Consequently, examples of a number of copolymers suitable for use to produce the high acid ionomers included in

the present invention include, but are not limited to, high acid embodiments of an ethylene/acrylic acid copolymer, an ethylene/methacrylic acid copolymer, an ethylene/itaconic acid copolymer, an ethylene/maleic acid copolymer, an ethylene/methacrylic acid/vinyl acetate copolymer, an ethylene/acrylic acid/vinyl alcohol copolymer, etc. The base copolymer broadly contains greater than 16% by weight unsaturated carboxylic acid, from about 30 to about 83% by weight ethylene and from 0 to about 40% by weight of a softening comonomer. Preferably, the copolymer contains about 20% by weight unsaturated carboxylic acid and about 80% by weight ethylene. Most preferably, the copolymer contains about 20% acrylic acid with the remainder being ethylene.

Along these lines, examples of the preferred high acid base copolymers which fulfill the criteria set forth above, are a series of ethylene-acrylic copolymers which are commercially available from The Dow Chemical Company, Midland, Mich., under the "Primacor" designation. These high acid base copolymers exhibit the typical properties set forth below in Table 1.

TABLE 1

Typical Properties of Primacor Ethylene-Acrylic Acid Copolymers							
GRADE ASTM	PERCENT ACID	DENSITY, gl/cc D-792	MELT INDEX, g/10 min D-1238	TENSILE YD. ST (psi) D-638	FLEXURAL MODULUS (psi) D-790	VICAT SOFT PT (° C.) D-1525	SHORE D HARDNESS D-2240
5980	20.0	0.958	300.0	—	4800	43	50
5990	20.0	0.955	1300.0	650	2600	40	42
5990	20.0	0.955	1300.0	650	3200	40	42
5981	20.0	0.960	300.0	900	3200	46	48
5981	20.0	0.960	300.0	900	3200	46	48
5983	20.0	0.958	500.0	850	3100	44	45
5991	20.0	0.953	2600.0	635	2600	38	40

<sup>1</sup>The Melt Index values are obtained according to ASTM D-1238, at 190° C.

Due to the high molecular weight of the Primacor 5981 grade of the ethylene-acrylic acid copolymer, this copolymer is the more preferred grade utilized in the invention.

The metal cation salts utilized in the invention are those salts which provide the metal cations capable of neutralizing, to various extents, the carboxylic acid groups of the high acid copolymer. These include acetate, oxide or hydroxide salts of lithium, calcium, zinc, sodium, potassium, nickel, magnesium, and manganese.

Examples of such lithium ion sources are lithium hydroxide monohydrate, lithium hydroxide, lithium oxide and lithium acetate. Sources for the calcium ion include calcium hydroxide, calcium acetate and calcium oxide. Suitable zinc ion sources are zinc acetate dihydrate and zinc acetate, a blend of zinc oxide and acetic acid. Examples of sodium ion sources are sodium hydroxide and sodium acetate. Sources for the potassium ion include potassium hydroxide and potassium acetate. Suitable nickel ion sources are nickel acetate, nickel oxide and nickel hydroxide. Sources of magnesium include magnesium oxide, magnesium hydroxide, magnesium acetate. Sources of manganese include manganese acetate and manganese oxide.

The new metal cation neutralized high acid ionomer resins are produced by reacting the high acid base copolymer with various amounts of the metal cation salts above the crystalline melting point of the copolymer, such as at a temperature from about 200° F. to about 500° F., preferably

from about 250° F. to about 350° F. under high shear conditions at a pressure of from about 10 psi to 10,000 psi. Other well known blending techniques may also be used. The amount of metal cation salt utilized to produce the new metal cation neutralized high acid based ionomer resins is the quantity which provides a sufficient amount of the metal cations to neutralize the desired percentage of the carboxylic acid groups in the high acid copolymer. The extent of neutralization is generally from about 10% to about 90%.

As indicated below in Table 2 and more specifically in Example 1 in U.S. application Ser. No. 901,680, a number of new types of metal cation neutralized high acid ionomers can be obtained from the above indicated process. These include new high acid ionomer resins neutralized to various extents with manganese, lithium, potassium, calcium and nickel cations. In addition, when a high acid ethylene/acrylic acid copolymer is utilized as the base copolymer component of the invention and this component is subsequently neutralized to various extents with the metal cation salts producing acrylic acid based high acid ionomer resins neutralized with cations such as sodium, potassium, lithium, zinc,

magnesium, manganese, calcium and nickel, several new cation neutralized acrylic acid based high acid ionomer resins are produced.

TABLE 2

Formulation No.	Wt % Cation Salt	Wt % Neutralization	Melt Index	C.O.R.	Shore D Hardness
1(NaOH)	6.98	67.5	0.9	.804	71
2(NaOH)	5.66	54.0	2.4	.808	73
3(NaOH)	3.84	35.9	12.2	.812	69
4(NaOH)	2.91	27.0	17.5	.812	(brittle)
5(MnAc)	19.6	71.7	7.5	.809	73
6(MnAc)	23.1	88.3	3.5	.814	77
7(MnAc)	15.3	53.0	7.5	.810	72
8(MnAc)	26.5	106	0.7	.813	(brittle)
9(LiOH)	4.54	71.3	0.6	.810	74
10(LiOH)	3.38	52.5	4.2	.818	72
11(LiOH)	2.34	35.9	18.6	.815	72
12(KOH)	5.30	36.0	19.3	Broke	70
13(KOH)	8.26	57.9	7.18	.804	70
14(KOH)	10.7	77.0	4.3	.801	67
15(ZnAc)	17.9	71.5	0.2	.806	71
16(ZnAc)	13.9	53.0	0.9	.797	69
17(ZnAc)	9.91	36.1	3.4	.793	67
18(MgAc)	17.4	70.7	2.8	.814	74
19(MgAc)	20.6	87.1	1.5	.815	76
20(MgAc)	13.8	53.8	4.1	.814	74
21(CaAc)	13.2	69.2	1.1	.813	74
22(CaAc)	7.12	34.9	10.1	.808	70



TABLE 2-continued

Formulation No.	Wt % Cation Salt	Wt % Neutralization	Melt Index	C.O.R.	Shore D Hardness
23(MgO)	2.91	53.5	2.5	.813	
24(MgO)	3.85	71.5	2.8	.808	
25(MgO)	4.76	89.3	1.1	.809	
26(MgO)	1.96	35.7	7.5	.815	
27(CNiAc)	13.04	61.1	0.2	.802	71
28(NfAc)	10.71	48.9	0.5	.799	72
29(NiAc)	8.26	36.7	1.8	.796	69
30(NiAc)	5.66	24.4	7.5	.786	64

Controls:  
50/50 Blend of Ioteks 8000/7030 C.O.R. = .810/65 Shore D Hardness  
DuPont High Acid Surlyn® 8422 (Na) C.O.R. = .811/70 Shore D Hardness  
DuPont High Acid Surlyn® 8162 (Zn) C.O.R. = .807/65 Shore D Hardness  
Exxon High Acid Iotek EX-960 (Zn) C.O.R. = .796/65 Shore D Hardness  
Control for Formulations 23–26 is 50/50 Iotek 8000/7030, C.O.R. = .814,  
Formulation 26 C.O.R. was normalized to that control accordingly  
Control for Formulation Nos. 27–30 is 50/50 Iotek 8000/7030, C.O.R. = .807

When compared to low acid versions of similar cation neutralized ionomer resins, the new metal cation neutralized high acid ionomer resins exhibit enhanced hardness, modulus and resilience characteristics. These are properties that are particularly desirable in a number of thermoplastic fields, including the field of golf ball manufacturing.

When utilized in the construction of the inner layer of a multi-layered golf ball, it has been found that the new acrylic acid based high acid ionomers extend the range of hardness beyond that previously obtainable while maintaining the beneficial properties (i.e. durability, click, feel, etc.) of the softer low acid ionomer covered balls, such as balls produced utilizing the low acid ionomers disclosed in U.S. Pat. Nos. 4,884,814 and 4,911,451.

Moreover, as a result of the development of a number of new acrylic acid based high[] acid ionomer resins neutralized to various extents by several different types of metal cations, such as manganese, lithium, potassium, calcium and nickel cations, several new ionomers or ionomer blends are now available for production of an inner cover layer of a multi-layered golf ball. By using these high acid ionomer resins, harder, stiffer inner cover layers having higher C.O.R.s, and thus longer distance, can be obtained.

More preferably, it has been found that when two or more of the above-indicated high acid ionomers, particularly blends of sodium and zinc high acid ionomers, are processed to produce the covers of multi-layered golf balls, (i.e., the inner cover layer herein) the resulting golf balls will travel further than previously known multi-layered golf balls produced with low acid ionomer resin covers due to the balls' enhanced coefficient of restitution values.

For example, the multi-layer golf ball taught in U.S. Pat. No. 4,650,193 does not incorporate a high acid ionomeric resin in the inner cover layer. As will be set forth below in the Examples, the coefficient of restitution of the golf ball having an inner layer taught by the '193 patent (i.e., inner layer composition "D" in the Examples) is substantially lower than the coefficient of restitution of the remaining compositions. In addition, the multi-layered ball disclosed in the '193 patent suffers substantially in durability in comparison with the present invention.

With respect to the outer layer 16 of the multi-layered cover of the present invention, the outer cover layer is comparatively softer than the high acid ionomer based inner layer. The softness provides for the feel and playability characteristics typically associated with balata or balata-

blend balls. The outer layer or ply is comprised of a relatively soft, low modulus (about 1,000 psi to about 10,000 psi) and low acid (less than 16 weight percent acid) ionomer, ionomer blend or a non-ionomeric thermoplastic elastomer such as, but not limited to, a polyurethane, a polyester elastomer such as that marketed by DuPont under the trademark Hytrel®, or a polyester amide such as that marketed by Elf Atochem S.A. under the trademark Pebax®. The outer layer is fairly thin (i.e. from about 0.010 to about 0.050 in thickness, more desirably 0.03 inches in thickness for a 1.680 inch ball), but thick enough to achieve desired playability characteristics while minimizing expense.

Preferably, the outer layer includes a blend of hard and soft (low acid) ionomer resins such as those described in U. S. Pat. Nos. 4,884,814 and 5,120,791, both incorporated herein by reference. Specifically, a desirable material for use in molding the outer layer comprises a blend of a high modulus (hard) ionomer with a low modulus (soft) ionomer to form a base ionomer mixture. A high modulus ionomer herein is one which measures from about 15,000 to about 70,000 psi as measured in accordance with ASTM method D-790. The hardness may be defined as at least 50 on the Shore D scale as measured in accordance with ASTM method D-2240.

A low modulus ionomer suitable for use in the outer layer blend has a flexural modulus measuring from about 1,000 to about 10,000 psi, with a hardness of about 20 to about 40 on the Shore D scale.

The hard ionomer resins utilized to produce the outer cover layer composition hard/soft blends include ionic copolymers which are the sodium, zinc, magnesium or lithium salts of the reaction product of an olefin having from 2 to 8 carbon atoms and an unsaturated monocarboxylic acid having from 3 to 8 carbon atoms. The carboxylic acid groups of the copolymer may be totally or partially (i.e. approximately 15–75 percent) neutralized.

The hard ionomeric resins are likely copolymers of ethylene and either acrylic and/or methacrylic acid, with copolymers of ethylene and acrylic acid being the most preferred. Two or more types of hard ionomeric resins may be blended into the outer cover layer compositions in order to produce the desired properties of the resulting golf balls.

As discussed earlier herein, the hard ionomeric resins introduced under the designation Escor® and sold under the designation "lotek" are somewhat similar to the hard ionomeric resins sold under the Surlyn® trademark. However, since the "lotek" ionomeric resins are sodium or zinc salts of poly(ethylene-acrylic acid) and the Surlyn® resins are zinc or sodium salts of poly(ethylene-methacrylic acid) some distinct differences in properties exist. As more specifically indicated in the data set forth below, the hard "lotek" resins (i.e., the acrylic acid based hard ionomer resins) are the more preferred hard resins for use in formulating the outer layer blends for use in the present invention. In addition, various blends of "lotek" and Surlyn® hard ionomeric resins, as well as other available ionomeric resins, may be utilized in the present invention in a similar manner.

Examples of commercially available hard ionomeric resins which may be used in the present invention in formulating the outer cover blends include the hard sodium ionic copolymer sold under the trademark Surlyn®8940 and the hard zinc ionic copolymer sold under the trademark Surlyn®9910. Surlyn®8940 is a copolymer of ethylene with methacrylic acid and about 15 weight percent acid which is about 29 percent neutralized with sodium ions. This resin has an average melt flow index of about 2.8. Surlyn®9910

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is a copolymer of ethylene and methacrylic acid with about 15 weight percent acid which is about 58 percent neutralized with zinc ions. The average melt flow index of Surlyn®9910

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is about 0.7. The typical properties of Surlyn®9910 and 8940 are set forth below in Table 3:

TABLE 3

Typical Properties of Commercially Available Hard Surlyn ®Resins Suitable for Use in the Outer Layer Blends of the Present Invention							
	ASTM D	8940	9910	8920	8528	9970	9730
Cation Type		Sodium	Zinc	Sodium	Sodium	Zinc	Zinc
Melt flow index, gms/10 min.	D-1238	2.8	0.7	0.9	1.3	14.0	1.6
Specific Gravity, g/cm <sup>3</sup>	D-792	0.95	0.97	0.95	0.94	0.95	0.95
Hardness, Shore D	D-2240	66	64	66	60	62	63
Tensile Strength, (kpsi), MPa	D-638	(4.8)	(3.6)	(5.4)	(4.2)	(3.2)	(4.1)
Elongation, %	D-638	33.1	24.8	37.2	29.0	22.0	28.0
Flexural Modulus, (kpsi) MPa	D-790	470	290	350	450	460	460
Tensile Impact (23° C.) KJ/m <sup>2</sup> (ft.-lbs./in <sup>2</sup> )	D-1822S	(51)	(48)	(55)	(32)	(28)	(30)
Vicat Temperature, ° C.	D-1525	350	330	380	220	190	210
		1020	1020	865	1160	760	1240
		(485)	(485)	(410)	(550)	(360)	(590)
		63	62	58	73	61	73

25 Examples of the more pertinent acrylic acid based hard ionomer resin suitable for use in the present outer cover composition sold under the “Iotek” tradename by the Exxon Corporation include Iotek 4000, Iotek 4010, Iotek 8000, Iotek 8020 and Iotek 8030. The typical properties of these and other Iotek hard ionomers suited for use in formulating the outer layer cover composition are set forth below in Table 4:

TABLE 4

Typical Properties of Iotek Ionomers							
Resin Properties	ASTM Method	Units	4000	4010	8000	8020	8030
Cation type			zinc	zinc	sodium	sodium	sodium
Melt index	D-1238	g/10 min.	2.5	1.5	0.8	1.6	2.8
Density	D-1505	kg/m <sup>3</sup>	963	963	954	960	960
Melting Point	D-3417	° C.	90	90	90	87.5	87.5
Crystallization Point	D-3417	° C.	62	64	56	53	55
Vicat Softening Point	D-1525	° C.	62	63	61	64	67
% Weight Acrylic Acid			16		15	15	15
% of Acid Groups cation neutralized			30		40		
Plaque Properties (3 mm thick, compression molded)							
Tensile at break	D-638	MPa	24	26	36	31.5	28
Yield point	D-638	MPa	none	none	21	21	23
Elongation at break	D-638	%	395	420	350	410	395
1% Secant modulus	D-638	MPa	160	160	300	350	390
Shore Hardness D	D-2240	—	55	55	61	58	59
Film Properties (50 micron film 2.2:1 Blow-up ratio)							
Tensile at Break							
MD	D-882	MPa	41	39	42	52	47.4
TD	D-882	MPa	37	38	38	38	40.5

TABLE 4-continued

Typical Properties of Iotek Ionomers						
Yield point						
MD	D-882	MPa	15	17	17	23
TD	D-882	MPa	14	15	15	21
Elongation at Break						
MD	D-882	%	310	270	260	295
TD	D-882	%	360	340	280	340
1% Secant modulus						
MD	D-882	MPa	210	215	390	380
TD	D-882	MPa	200	225	380	350
Dart Drop Impact	D-1709	g/micron	12.4	12.5	20.3	
Resin Properties						
	ASTM Method	Units	7010	7020	7030	
Cation type			zinc	zinc	zinc	
Melt Index	D-1238	g/10 min.	0.8	1.5	2.5	
Density	D-1505	kg/m <sup>3</sup>	960	960	960	
Melting Point	D-3417	° C.	90	90	90	
Crystallization Point	D-3417	° C.	—	—	—	
Vicat Softening Point	D-1525	° C.	60	63	62.5	
% Weight Acrylic Acid			—	—	—	
% of Acid Groups			—	—	—	
Cation Neutralized						
Plaque Properties (3 mm thick, compression molded)						
Tensile at break	D-638	MPa	38	38	38	
Yield Point	D-638	MPa	none	none	none	
Elongation at break	D-638	%	500	420	395	
1% Secant modulus	D-638	MPa	—	—	—	
Shore Hardness D	D-2240	—	57	55	55	

Comparatively, soft ionomers are used in formulating the hard/soft blends of the outer cover composition. These ionomers include acrylic acid based soft ionomers. They are generally characterized as comprising sodium or zinc salts of a terpolymer of an olefin having from about 2 to 8 carbon atoms, acrylic acid, and an unsaturated monomer of the acrylate ester class having from 1 to 21 carbon atoms. The soft ionomer is preferably a zinc based ionomer made from an acrylic acid base polymer in an unsaturated monomer of the acrylate ester class. The soft (low modulus) ionomers have a hardness from about 20 to about 40 as measured on the Shore D scale and a flexural modulus from about 1,000 to about 10,000, as measured in accordance with ASTM method D-790.

Certain ethylene-acrylic acid based soft ionomer resins developed by the Exxon Corporation under the designation "Iotek 7520" (referred to experimentally by differences in neutralization and melt indexes as LDX 195, LDX 196, LDX 218 and LDX 219) may be combined with known hard ionomers such as those indicated above to produce the outer cover. The combination produces higher C.O.R.s at equal or softer hardness, higher melt flow (which corresponds to improved, more efficient molding, i.e., fewer rejects) as well as significant cost savings versus the outer layer of multi-layer balls produced by other known hard-soft ionomer blends as a result of the lower overall raw materials costs and improved yields.

While the exact chemical composition of the resins to be sold by Exxon under the designation Iotek 7520 is considered by Exxon to be confidential and proprietary

information, Exxon's experimental product data sheet lists the following physical properties of the ethylene acrylic acid zinc ionomer developed by Exxon:

TABLE 5

Physical Properties of Iotek 7520			
Property	ASTM Method	Units	Typical Value
Melt Index	D-1238	g/10 min.	2
Density	D-1505	kg/m <sup>3</sup>	0.962
Cation			Zinc
Melting Point	D-3417	° C.	66
Crystallization Point	D-3417	° C.	49
Vicat Softening Point	D-1525	° C.	42
Plaque Properties (2 mm thick Compression Molded Plaques)			
Tensile at Break	D-638	MPa	10
Yield Point	D-638	MPa	None
Elongation at Break	D-638	%	760
1% Secant Modulus	D-638	MPa	22
Shore D Hardness	D-2240		32
Flexural Modulus	D-790	MPa	26
Zwick Rebound	ISO 4862	%	52
De Mattia Flex Resistance	D-430	Cycles	>5000

In addition, test data collected by the inventor indicates that Iotek 7520 resins have Shore D hardnesses of about 32 to 36 (per ASTM D-2240), melt flow indexes of 3±0.5 g/10 min (at 190° C. per ASTM D-1288), and a flexural modulus

of about 2500–3500 psi (per ASTM D-790). Furthermore, testing by an independent testing laboratory by pyrolysis mass spectrometry indicates that lotek 7520 resins are generally zinc salts of a terpolymer of ethylene, acrylic acid, and methyl acrylate.

Furthermore, the inventor has found that a newly developed grade of an acrylic acid based soft ionomer available from the Exxon Corporation under the designation lotek 7510, is also effective, when combined with the hard ionomers indicated above in producing golf ball covers exhibiting higher C.O.R. values at equal or softer hardness than those produced by known hard-soft ionomer blends. In this regard, lotek 7510 has the advantages (i.e. improved flow, higher C.O.R. values at equal hardness, increased clarity, etc.) produced by the lotek 7520 resin when compared to the methacrylic acid base soft ionomers known in the art (such as the Surlyn 8625 and the Surlyn 8629 combinations disclosed in U.S. Pat. No. 4,884,814).

In addition, lotek 7510, when compared to lotek 7520, produces slightly higher C.O.R. values at equal softness/hardness due to the lotek 7510's higher hardness and neutralization. Similarly, lotek 7510 produces better release properties (from the mold cavities) due to its slightly higher stiffness and lower flow rate than lotek 7520. This is important in production where the soft covered balls tend to have lower yields caused by sticking in the molds and subsequent punched pin marks from the knockouts.

According to Exxon, lotek 7510 is of similar chemical composition as lotek 7520 (i.e. a zinc salt of a terpolymer of ethylene, acrylic acid, and methyl acrylate) but is more highly neutralized. Based upon FTIR analysis, lotek 7520 is estimated to be about 30–40 wt.-% neutralized and lotek 7510 is estimated to be about 40–60 wt.-% neutralized. The typical properties of lotek 7510 in comparison of those of lotek 7520 are set forth below:

TABLE 6

Physical Properties of Iotek 7510 in Comparison to Iotek 7520		
	IOTEK 7520	IOTEK 7510
MI, g/10 min	2.0	0.8
Density, g/cc	0.96	0.97
Melting Point, ° F.	151	149
Vicat Softening Point, ° F.	108	109
Flex Modulus, psi	3800	5300
Tensile Strength, psi	1450	1750
Elongation, %	760	690
Hardness, Shore D	32	35

It has been determined that when hard/soft ionomer blends are used for the outer cover layer, good results are achieved when the relative combination is in a range of about 90 to about 10 percent hard ionomer and about 10 to about 90 percent soft ionomer. The results are improved by adjusting the range to about 75 to 25 percent hard ionomer and 25 to 75 percent soft ionomer. Even better results are noted at relative ranges of about 60 to 90 percent hard ionomer resin and about 40 to 60 percent soft ionomer resin.

Specific formulations which may be used in the cover composition are included in the examples set forth in U. S. Pat. Nos. 5,120,791 and 4,884,814. The present invention is in no way limited to those examples.

Moreover, in alternative embodiments, the outer cover layer formulation may also comprise a soft, low modulus non-ionomeric thermoplastic elastomer including a polyester polyurethane such as B. F. Goodrich Company's Estane®

polyester polyurethane X4517. According to B. F. Goodrich, Estane® X-4517 has the following properties:

Properties of Estane® X-4517	
Tensile	1430
100%	815
200%	1024
300%	1193
Elongation	641
Youngs Modulus	1826
Hardness A/D	88/39
Bayshore Rebound	59
Solubility in Water	Insoluble
Melt processing temperature	>350° F. (>177° C.)
Specific Gravity (H <sub>2</sub> O = 1)	1.1–1.3

Other soft, relatively low modulus non-ionomeric thermoplastic elastomers may also be utilized to produce the outer cover layer as long as the non-ionomeric thermoplastic elastomers produce the playability and durability characteristics desired without adversely effecting the enhanced travel distance characteristic produced by the high acid ionomer resin composition.

These include, but are not limited to thermoplastic polyurethanes such as: Texin thermoplastic polyurethanes from Mobay Chemical Co. and the Pellethane thermoplastic polyurethanes from Dow Chemical Co.; Ionomer/rubber blends such as those in Spalding U.S. Pat. Nos. 4,986,545; 5,098, 105 and 5,187,013; and, Hytrel polyester elastomers from DuPont and Pebax polyesteramides from Elf Atochem S.A.

In preparing golf balls in accordance with the present invention, a hard inner cover layer is molded (by injection molding or by compression molding) about a core (preferably a solid core). A comparatively softer outer layer is molded over the inner layer.

The conventional solid core is about 1.545 inches in diameter, although it can range from about 1.470 to about 1.575 inches. Conventional solid cores are typically compression molded from a slug of uncured or lightly cured elastomer composition comprising a high cis content polybutadiene and a metal salt of an  $\alpha$ ,  $\beta$ , ethylenically unsaturated carboxylic acid such as zinc mono or diacrylate or methacrylate. To achieve higher coefficients of restitution in the core, the manufacturer may include fillers such as small amounts of a metal oxide such as zinc oxide. In addition, larger amounts of metal oxide than those that are needed to achieve the desired coefficient are often included in conventional cores in order to increase the core weight so that the finished ball more closely approaches the U.S.G.A. upper weight limit of 1.620 ounces. Other materials may be used in the core composition including compatible rubbers or ionomers, and low molecular weight fatty acids such as stearic acid. Free radical initiators such as peroxides are admixed with the core composition so that on the application of heat and pressure, a complex curing cross-linking reaction takes place.

The core compositions of the present invention comprise one or more rubber or elastomeric components and an array of non-rubber or non-elastomeric components. The rubber components of the core compositions of the invention comprise a particular polybutadiene synthesized with cobalt and having an ultra-high Mooney viscosity and certain molecular weight characteristics described in detail below, one or more particular polybutadienes synthesized with neodymium, and one or more other optional polybutadienes. In some applications, polybutadienes synthesized with

nickel catalysts may be used in combination with or instead of polybutadienes synthesized with cobalt catalysts. And, polybutadienes synthesized with lanthanide series catalysts may be used in combination with or instead of polybutadienes synthesized with neodymium catalysts. The non-rubber components of the core compositions of the invention comprise one or more crosslinking agents which preferably include an unsaturated carboxylic acid component, a free radical initiator to promote cross linking, one or more optional modifying agents, fillers, moldability additives, processing additives, and dispersing agents, all of which are described in greater detail below.

The first preferred polybutadiene resin for use in the present invention composition has a relatively ultra high Mooney viscosity. A “Mooney unit” is an arbitrary unit used to measure the plasticity of raw, or unvulcanized rubber. The plasticity in Mooney units is equal to the torque, measured on an arbitrary scale, on a disk in a vessel that contains rubber at a temperature of 212° F. (100° C.) and that rotates at two revolutions per minute.

The measurement of Mooney viscosity, i.e. Mooney viscosity [ML<sub>1+4</sub>(100° C.)], is defined according to the standard ASTM D-1646, herein incorporated by reference. In ASTM D-1646, it is stated that the Mooney viscosity is not a true viscosity, but a measure of shearing torque over a range of shearing stresses. Measurement of Mooney viscosity is also described in the *Vanderbilt Rubber Handbook*, 13th Ed., (1990), pages 565–566, also herein incorporated by reference. Generally, polybutadiene rubbers have Mooney viscosities, measured at 212° F., of from about 25 to about 65. Instruments for measuring Mooney viscosities are commercially available such as a Monsanto Mooney Viscometer, Model MV 2000. Another commercially available device is a Mooney viscometer made by Shimadzu Seisakusho Ltd.

As will be understood by those skilled in the art, polymers may be characterized according to various definitions of molecular weight. The “number average molecular weight,” M<sub>n</sub>, is defined as:

$$M_n = \frac{\sum W_i}{\sum W_i / M_i}$$

where W<sub>i</sub> is the molecular weight of a fraction or sample of the polymer and M<sub>i</sub> is the total number of fractions or samples.

“Weight average molecular weight,” M<sub>w</sub>, is defined as:

$$M_w = \frac{\sum W_i M_i}{\sum W_i}$$

where W<sub>i</sub> and M<sub>i</sub> have the same meanings as noted above. The “Z-average molecular weight,” M<sub>z</sub>, is defined as:

$$M_z = \frac{\sum W_i M_i^2}{\sum W_i M_i}$$

where W<sub>i</sub> and M<sub>i</sub> have the same meanings as noted above. “M<sub>peak</sub>” is the molecular weight of the most common fraction or sample, i.e. having the greatest population.

Considering these various measures of molecular weight, provides an indication of the distribution or rather the “spread” of molecular weights of the polymer under review.

A common indicator of the degree of molecular weight distribution of a polymer is its “polydispersity”, P:

$$P = \frac{M_w}{M_n}$$

Polydispersity, also referred to as “dispersity”, also provides an indication of the extent to which the polymer chains share the same degree of polymerization. If the polydispersity is 1.0, then all polymer chains must have the same degree of polymerization. Since weight average molecular weight is always equal to or greater than the number average molecular weight, polydispersity, by definition, is equal to or greater than 1.0:

$$P \geq 1.0$$

The first particular polybutadiene for use in the preferred embodiment compositions of the present invention exhibits a Mooney viscosity of from about 65 to about 85, and preferably from about 70 to about 83. The first particular polybutadiene has a number average molecular weight M<sub>n</sub> of from about 90,000 to about 130,000; and preferably from about 100,000 to about 120,000. The first particular polybutadiene has a weight average molecular weight M<sub>w</sub> of from about 250,000 to about 350,000; and preferably from about 290,000 to about 310,000. The first particular polybutadiene has a Z-average molecular weight M<sub>z</sub> of about 600,000 to about 750,000; and preferably from about 660,000 to about 700,000. The first particular polybutadiene has a peak molecular weight M<sub>peak</sub> of about 150,000 to about 200,000; and preferably from about 170,000 to about 180,000.

The polydispersity of the first particular polybutadiene for use in the preferred embodiment compositions typically ranges from about 1.9 to about 3.9; and preferably from about 2.4 to about 3.1. Most preferably, the polydispersity is about 2.7.

The first particular polybutadiene for use in the preferred embodiment compositions preferably contains a majority fraction of polymer chains containing a cis-1,4 bond, more preferably, having a cis-1,4 polybutadiene content of about 90%, and most preferably, having a cis-1,4 polybutadiene content of at least about 95%. Another characteristic of the first preferred polybutadiene is that it is obtained or synthesized by utilizing a cobalt or cobalt-based catalyst. As noted herein, in some applications, a polybutadiene synthesized by using a nickel catalyst may be employed with, or in place of, the polybutadiene synthesized with a cobalt catalyst.

A commercially available polybutadiene corresponding to the noted first preferred ultra high viscosity polybutadiene, and which is suitable for use in the preferred embodiment compositions in accordance with the present invention is available under the designation Cariflex BCP 820, from Shell Chimie of France. Although this polybutadiene produces cores exhibiting higher C.O.R. values, it is somewhat difficult to process using conventional equipment. The properties and characteristics of this preferred polybutadiene are set forth below in Table 7.

TABLE 7

Properties of Shell Chimie BCP 820 (Also Known As BR-1220X)	
Property	Value
Mooney Viscosity (approximate)	70–83
Volatiles Content	0.5% maximum
Ash Content	0.1% maximum
Cis 1,4-polybutadiene Content	95.0% minimum

TABLE 7-continued

Properties of Shell Chimie BCP 820 (Also Known As BR-1220X)		
Stabilizer Content	0.2 to 0.3%	
Polydispersity	2.4–3.1	
Molecular Weight Data:	Trial 1	Trial 2
M <sub>n</sub>	110,000	111,000
M <sub>w</sub>	300,000	304,000
M <sub>z</sub>	680,000	
M <sub>peak</sub>	175,000	

The second polybutadiene for use in the preferred embodiment golf ball core compositions is a polybutadiene that is obtained or synthesized by utilizing a neodymium or lanthanide series catalyst, and that exhibits a Mooney viscosity of from about 30 to about 70, preferably from about 35 to about 70, more preferably from about 40 to about 65, and most preferably from about 45 to about 60. While the second polybutadiene provides covers exhibiting higher C.O.R. values, it exhibits very poor cold flow properties and very high dry swell characteristics.

Examples of such second polybutadienes obtained by using a neodymium-based catalyst include Neo Cis 40, Neo Cis 60 from Enichem. The properties of these polybutadienes are given below.

TABLE 8

Properties of Neo Cis		
Properties of Raw Polymer		
<u>Microstructure</u>		
1,4 cis (typical)		97.5%
1,4 trans (typical)		1.7%
Vinyl (typical)		0.8%
Volatile Matter (max)		0.75%
Ash (max)		0.30%
Stabilizer (typical)		0.50%
Mooney Viscosity, ML 1 + 4 at 100° C.	38—48 and 60—66	
Properties of compound (typical)		
<u>Vulcanization at 145° C.</u>		
Tensile strength, 35' cure,		16 MPa
Elongation, 35' cure,		440%
300% modulus, 35' cure,		9.5 MPa

It has been found that when the first and second polybutadienes are blended together within certain ranges, golf ball cores can be produced without the individual processing difficulties associated with each polybutadiene. In essence, a synergistic effect is produced allowing the blends to produce golf ball cores using conventional equipment exhibiting enhanced resilience.

The compositions of the present invention may also utilize other polybutadiene resins in addition to the noted first and second particular polybutadienes. For example, Cariflex BR-1220 polybutadiene available from Shell Chemical (see Table 9 below); and Taktene 220 polybutadiene available from Bayer Corp. of Orange, Tex. (see Tables 10A and 10B below) may be utilized as other polybutadienes in combination with the particular ultra-high Mooney viscosity polybutadiene components described herein. It is also contemplated that these polybutadienes could be used by themselves and without the particular first and second polybutadienes. Generally, these other polybutadienes have Mooney viscosities in the range of about 25 to 65. It is also contemplated that a similar polybutadiene resin,

BCP 819, commercially available from Shell Chimie, may be used in conjunction with BCP 820.

TABLE 9

Properties of Cariflex BR-1220 Polybutadiene		
Physical Properties:		
Polybutadiene Rubber		
CIS 1,4 Content - 97%–99% Min.		
Stabilizer Type - Non Staining		
Total Ash - 0.5% Max.		
Specific Gravity - 0.90–0.92		
Color - Transparent, clear, Lt. Amber		
Moisture - 0.3% max. ASTM 1416.76 Hot Mill Method		
Polymer Mooney Viscosity - (35–45 Cariflex) (ML 1 + 4 @ 212° F.)		
90% Cure - 10.0–13.0		
Polydispersity 2.5–3.5		

Molecular Weight Data:	Trial 1	Trial 2
M <sub>n</sub>	80,000	73,000
M <sub>w</sub>	220,000	220,000
M <sub>z</sub>	550,000	
M <sub>peak</sub>	110,000	

TABLE 10A

Properties of Taktene 220 Polybutadiene		
Physical Properties:		
Polybutadiene Rubber		
CIS 1,4 Content (%) - 98% Typical		
Stabilizer Type - Non Staining 1.0–1.3%		
Total Ash - 0.25 Max.		
Raw Polymer Mooney Visc. –35–45 40 Typical (ML 1 + 4' @212 Deg. F./212° F.)		
Specific Gravity - 0.91		
Color - Transparent - almost colorless (15 APHA Max.)		
Moisture % - 0.30% Max. ASTM 1416-76 Hot Mill Method		

TABLE 10B

Properties of Taktene 220 Polybutadiene		
Product Description		
A low Mooney viscosity, non-staining, solution polymerized, high cis-1,4-polybutadiene rubber.		
Property	Range	Test Method
Raw Polymer Properties		
Mooney viscosity 1 + 4 (212° F.)	40 ± 5	ASTM D 1646
Volatile matter (wt %)	0.3 max.	ASTM D 1416
Total Ash (wt %)	0.25 max.	ASTM D 1416
Cure <sup>(1)(2)</sup> Characteristics		
Minimum torque		
M <sub>L</sub> (dN.m)	9.7 ± 2.2	ASTM D 2084
(lbf.in)	8.6 ± 1.9	ASTM D 2084
Maximum torque		
M <sub>H</sub> (dN.m)	35.7 ± 4.8	ASTM D 2084
(lbf.in)	31.6 ± 4.2	ASTM D 2084
t <sub>1</sub> (min)	4 ± 1.1	ASTM D 2084
t <sub>50</sub> (min)	9.6 ± 2.5	ASTM D 2084
t <sub>90</sub> (min)	12.9 ± 3.1	ASTM D 2084

TABLE 10B-continued

Properties of Taktene 220 Polybutadiene	
Other Product Features	
Property	Typical Value
Specific gravity	0.91
Stabilizer type	Non-staining
<sup>(1)</sup> Monsanto Rheometer at 160° C., 1.7 Hz (100 cpm), 1 degree arc, micro-die	
<sup>(2)</sup> Cure characteristics determined on ASTM D 3189 MIM mixed compound: TAKTENE 220	
	100 (parts by mass)
Zinc oxide	3
Stearic acid	2
IRB #6 black (N330)	60
Naphthenic oil	15
TBBS	0.9
Sulfur	1.5
* This specification refers to product manufactured by Bayer Corp., Orange, Texas, U.S.A.	

Concerning the elastomeric or rubber portion of the preferred embodiment compositions, it is preferred to utilize the previously described first and second polybutadienes in particular proportions to one another. Generally, it is preferred to utilize the first polybutadiene in a proportion of less than 50 parts per hundred parts of the total amount of the first and second polybutadienes. Unless indicated otherwise, all parts expressed herein are parts by weight. More preferably, the first polybutadiene is utilized in a proportion of about 45 parts or less (most preferably 40 parts or less) per hundred parts of the total amount of the first and second polybutadienes. With respect to the second polybutadiene, it is generally preferred to utilize the second polybutadiene in a proportion of more than 50 parts per hundred parts of the total amount of the first and second polybutadienes. More preferably, the second polybutadiene is utilized in a proportion of about 55 parts or more (most preferably 60 parts or more) per hundred parts of the total amount of the first and second polybutadienes.

The preferred embodiment core compositions of the present invention generally comprise from about 80 parts to about 120 parts by weight of elastomeric or rubber components, i.e. the first and second polybutadienes, and from about 60 to about 80, or more, parts by weight of non-rubber or non-elastomeric components. Preferably, the core compositions comprise about 100 parts of rubber components and from about 60 to about 80, or more, parts by weight of non-rubber components. It will be understood that depending upon the types and respective function of components added to the non-rubber portion of the preferred embodiment core compositions, that the non-rubber portion may constitute a significant proportion of the rubber component. The rubber components include the previously described first and second polybutadienes. The non-rubber components are as follows.

Preferably, the crosslinking agent of the core composition is an unsaturated carboxylic acid component which is the reaction product of a carboxylic acid or acids and an oxide or carbonate of a metal such as zinc, magnesium, barium, calcium, lithium, sodium, potassium, cadmium, lead, tin, and the like. Preferably, the oxides of polyvalent metals such as zinc, magnesium and cadmium are used, and most preferably, the oxide is zinc oxide.

Exemplary of the unsaturated carboxylic acids which find utility in the preferred core compositions are acrylic acid,

methacrylic acid, itaconic acid, crotonic acid, sorbic acid, and the like, and mixtures thereof. Preferably, the acid component is either acrylic or methacrylic acid. Usually, from about 15 to about 50, and preferably from about 20 to about 35 parts by weight of the carboxylic acid salt, such as zinc diacrylate, is included per 100 parts of the rubber components in the core composition. The unsaturated carboxylic acids and metal salts thereof are generally soluble in the elastomeric base, or are readily dispersible.

The free radical initiator included in the core composition is any known polymerization initiator (a co-crosslinking agent) which decomposes during the cure cycle. The term "free radical initiator" as used herein refers to a chemical which, when added to a mixture of the elastomeric blend and a metal salt of an unsaturated, carboxylic acid, promotes crosslinking of the elastomers by the metal salt of the unsaturated carboxylic acid. The amount of the selected initiator present is dictated only by the requirements of catalytic activity as a polymerization initiator. Suitable initiators include peroxides, persulfates, azo compounds and hydrazides. Peroxides which are readily commercially available are conveniently used in the present invention, generally in amounts of from about 0.1 to about 10.0 and preferably in amounts of from about 0.3 to about 3.0 parts by weight per each 100 parts of elastomer.

Exemplary of suitable peroxides for the purposes of the present invention are dicumyl peroxide, n-butyl 4,4'-bix (butylperoxy) valerate, 1,1-bis (t-butylperoxy) -3,3,5-trimethyl cyclohexane, di-t-butyl peroxide and 2,5-di-(t-butylperoxy)-2,5 dimethyl hexane and the like, as well as mixtures thereof. It will be understood that the total amount of initiators used will vary depending on the specific end product desired and the particular initiators employed.

Examples of such commercial available peroxides are Luperco 230 or 231 XL, a peroxyketal manufactured and sold by Atochem, Lucidol Division, Buffalo, N. Y., and Trigonox 17/40 or 29/40, a peroxyketal manufactured and sold by Akzo Chemie America, Chicago, Ill. The one hour half life of Luperco 231 XL and Trigonox 29/40 is about 112° C., and the one hour half life of Luperco 230 XL and Trigonox 17/40 is about 129° C. Luperco 230 XL and Trigonox 17/40 are n-butyl-4,4-bis(t-butylperoxy) valerate and Luperco 231 XL and Trigonox 29/40 are 1,1-di(t-butylperoxy) 3,3,5-trimethyl cyclohexane. Most preferably, and as noted in Table 6 herein, Trigonox 42-40B from Akzo Nobel of Chicago, Ill. is used. Most preferably, a solid form of this peroxide is used. Trigonox 42-40B is tert-Butyl peroxy-3,5,5-trimethylhexanoate. The liquid form of this agent is available from Akzo under the designation Trigonox 42S.

The core compositions of the present invention may additionally contain any other suitable and compatible modifying ingredients including, but not limited to, metal oxides, fatty acids, and diisocyanates. For example, Papi 94, a polymeric diisocyanate, commonly available from Dow Chemical Co., Midland, Mich., is an optional component in the rubber compositions. It can range from about 0 to 5 parts by weight per 100 parts by weight rubber (phr) component, and acts as a moisture scavenger.

Various activators may also be included in the compositions of the present invention. For example, zinc oxide and/or magnesium oxide are activators for the polybutadiene. The activator can range from about 2 to about 10 parts by weight per 100 parts by weight of the rubbers (phr) component.

Moreover, filler-reinforcement agents may be added to the composition of the present invention. One such example is

polypropylene powder. Since the specific gravity of polypropylene powder is very low, and when compounded, the polypropylene powder produces a lighter molded core, large amounts of higher gravity fillers may be added. Additional benefits may be obtained by the incorporation of relatively large amounts of higher specific gravity, inexpensive mineral fillers such as calcium carbonate. Such fillers as are incorporated into the core compositions should be in finely divided form, as for example, in a size generally less than about 30 mesh and preferably less than about 100 mesh U.S. standard size. The amount of additional filler included in the core composition is primarily dictated by weight restrictions and preferably is included in amounts of from about 10 to about 100 parts by weight per 100 parts rubber.

The preferred fillers are relatively inexpensive and heavy and serve to lower the cost of the ball and to increase the weight of the ball to closely approach the U.S.G.A. weight limit of 1.620 ounces. Exemplary fillers include mineral fillers such as limestone, zinc oxide, silica, mica, barytes, calcium carbonate, or clays. Limestone is ground calcium/magnesium carbonate and is used because it is an inexpensive, heavy filler. Other heavy filler include metal particles, such as powdered tungsten, bismuth, or molybdenum. Other filler materials are noted herein.

As indicated, ground flash filler may be incorporated and is preferably 20 mesh ground up center stock from the excess flash from compression molding. It lowers the cost and may increase the hardness of the ball.

Fatty acids or metallic salts of fatty acids may also be included in the compositions, functioning to improve moldability and processing. Generally, free fatty acids having from about 10 to about 40 carbon atoms, and preferably having from about 15 to about 20 carbon atoms, are used. Exemplary of suitable fatty acids are stearic acid, palmitic, oleic and linoleic acids, as well as mixtures thereof. Exemplary of suitable metallic salts of fatty acids include zinc stearate. When included in the core compositions, the fatty acid component is present in amounts of from about 1 to about 25, preferably in amounts from about 20 to about 15 parts by weight based on 100 parts rubber (elastomer). It is preferred that the core compositions include stearic acid as the fatty acid adjunct in an amount of from about 2 to about 5 parts by weight per 100 parts of rubber.

Diisocyanates may also be optionally included in the core compositions when utilized, the diisocyanates are included in amounts of from about 0.2 to about 5.0 parts by weight based on 100 parts rubber. Exemplary of suitable diisocyanates is 4,4'-diphenylmethane diisocyanate and other polyfunctional isocyanates known to the art.

Furthermore, the dialkyl tin difatty acids set forth in U.S. Pat. No. 4,844,471, the dispersing agents disclosed in U.S. Pat. No. 4,838,556, and the dithiocarbonates set forth in U.S. Pat. No. 4,852,884 may also be incorporated into the polybutadiene compositions of the present invention. The specific types and amounts of such additives are set forth in the above-identified patents, which are incorporated herein by reference.

The golf ball core compositions of the invention may also comprise from about 1 to about 100 parts by weight of particulate polypropylene resin, and preferably from about 10 to about 100 parts by weight polypropylene powder resin, per 100 parts by weight of a base elastomer (or rubber) selected from polybutadiene and mixtures of polybutadiene with other elastomers. More preferably, the particulate polypropylene resin, if utilized in the core compositions of the present invention, comprises from about 20 to about 40 parts by weight of a polypropylene powder resin such as that

trademarked and sold by Amoco Chemical Co. under the designation "6400 P", "7000P" and "7200 P". The ratios of the ingredients may vary and are best optimized empirically.

As indicated above, additional suitable and compatible modifying agents such as fatty acids, and secondary additives such as Pecan shell flour, ground flash (i.e. grindings from previously manufactured cores of substantially identical construction), barium sulfate, zinc oxide, etc. may be added to the core compositions to increase the weight of the ball as necessary in order to have the ball reach or closely approach the U.S.G.A. weight limit of 1.620 ounces.

The inner cover layer which is molded over the core is about 0.100 inches to about 0.010 inches in thickness, preferably about 0.0375 inches thick. The outer cover layer is about 0.010 inches to about 0.060 inches in thickness, preferably 0.0300 inches thick. Together, the core, the inner cover layer and the outer cover layer combine to form a ball having a diameter of 1.680 inches or more, the minimum diameter permitted by the rules of the United States Golf Association and weighing about 1.620 ounces.

Additional materials may be added to the cover compositions (both inner and outer cover layer) of the present invention including dyes (for example, Ultramarine Blue sold by Whitaker, Clark and Daniels of South Plainsfield, N.J.) (see U.S. Pat. No. 4,679,795); pigments such as titanium dioxide, zinc oxide, barium sulfate and zinc sulfate; and UV absorbers; antioxidants; antistatic agents; and stabilizers. Further, the cover compositions of the present invention may also contain softening agents, such as plasticizers, processing aids, etc. and reinforcing material such as glass fibers and inorganic fillers, as long as the desired properties produced by the golf ball covers are not impaired.

The various cover composition layers of the present invention may be produced according to conventional melt blending procedures. In the case of the outer cover layer, when a blend of hard and soft, low acid ionomer resins are utilized, the hard ionomer resins are blended with the soft ionomeric resins and with a masterbatch containing the desired additives in a Banbury mixer, two-roll mill, or extruder prior to molding. The blended composition is then formed into slabs and maintained in such a state until molding is desired. Alternatively, a simple dry blend of the pelletized or granulated resins and color masterbatch may be prepared and fed directly into the injection molding machine where homogenization occurs in the mixing section of the barrel prior to injection into the mold. If necessary, further additives such as an inorganic filler, etc., may be added and uniformly mixed before initiation of the molding process. A similar process is utilized to formulate the high acid ionomer resin compositions used to produce the inner cover layer.

The golf balls of the present invention can be produced by molding processes currently well known in the golf ball art. Specifically, the golf balls can be produced by injection molding or compression molding the inner cover layer about wound or solid molded cores to produce an intermediate golf ball having a diameter of about 1.50 to 1.67 inches, preferably about 1.620 inches. The outer layer is subsequently molded over the inner layer to produce a golf ball having a diameter of 1.680 inches or more. Although either solid cores or wound cores can be used in the present invention, as a result of their lower cost and superior performance, solid molded cores are preferred over wound cores.

In compression molding, the inner cover composition is formed via injection at about 380° F. to about 450° F. into smooth surfaced hemispherical shells which are then positioned around the core in a mold having the desired inner



cover thickness and subjected to compression molding at 200° to 300° F. for about 2 to 10 minutes, followed by cooling at 50° to 70° F. for about 2 to 7 minutes to fuse the shells together to form a unitary intermediate ball. In addition, the intermediate balls may be produced by injection molding wherein the inner cover layer is injected directly around the core placed at the center of an intermediate ball mold for a period of time in a mold temperature of from 50° F. to about 100° F. Subsequently, the outer cover layer is molded about the core and the inner layer by similar compression or injection molding techniques to form a dimpled golf ball of a diameter of 1.680 inches or more.

After molding, the golf balls produced may undergo various further processing steps such as buffing, painting and marking as disclosed in U.S. Pat. No. 4,911,451.

The resulting golf ball produced from the high acid ionomer resin inner layer and the relatively softer, low flexural modulus outer layer provide for an improved multi-layer golf ball which provides for desirable coefficient of restitution and durability properties while at the same time offering the feel and spin characteristics associated with soft balata and balata-like covers of the prior art.

The present invention is further illustrated by the following examples in which the parts of the specific ingredients are by weight. It is to be understood that the present invention is not limited to the examples, and various changes and modifications may be made in the invention without departing from the spirit and scope thereof.

EXAMPLES

Several intermediate balls (cores plus inner cover layers) were prepared in accordance with conventional molding procedures described above. The inner cover compositions were molded around 1.545 inch diameter cores weighing 36.5 grams such that the inner cover had a wall thickness of about 0.0675 inches, with the overall ball measuring about 1.680 inches in diameter.

The cores utilized in the examples were comprised of the following ingredients: high cis-polybutadiene, zinc diacrylate, zinc oxide, zinc stearate, peroxide, calcium carbonate, etc. The molded cores exhibited Riehle compressions of about 60 and C.O.R. values of about 0.800. A representative formulation of the molded cores is set forth below:

MATERIAL	WEIGHT
BR-1220 (high cis-polybutadiene)	70.70
Taktene 220 (high cis-polybutadiene)	29.30
React Rite ZDA (zinc diacrylate)	31.14
Zinc Oxide	6.23
Zinc Stearate	20.15
Limestone	17.58
Ground Flash (20-40 Mesh)	20.15
Blue Masterbatch	.012
Luperco 231XL	.89
or Trigonox 29/40	
Papi 94	.50

<sup>1</sup>Blue Masterbatch consists of unknown compositions used only for internal identification purposes and has no effect on physical properties.

The inner cover compositions designated herein as compositions A-E utilized to formulate the intermediate balls are set forth in Table 11 below. The resulting molded intermediate balls were tested to determine the individual compression (Riehle), C.O.R., Shore C hardness, spin rate and cut resistance properties. These results are also set forth in Table 11 below.

The data of these examples are the average of twelve intermediate balls produced for each example. The properties were measured according to the following parameters:

Coefficient of Restitution

The resilience or coefficient of restitution (COR) of a golf ball is the constant “e,” which is the ratio of the relative velocity of an elastic sphere after direct impact to that before impact. As a result, the COR (“e”) can vary from 0 to 1, with 1 being equivalent to a perfectly or completely elastic collision and 0 being equivalent to a perfectly or completely inelastic collision.

COR, along with additional factors such as club head speed, club head mass, ball weight, ball size and density, spin rate, angle of trajectory and surface configuration (i.e., dimple pattern and area of dimple coverage) as well as environmental conditions (e.g. temperature, moisture, atmospheric pressure, wind, etc.) generally determine the distance a ball will travel when hit. Along this line, the distance a golf ball will travel under controlled environmental conditions is a function of the speed and mass of the club and size, density and resilience (COR) of the ball and other factors. The initial velocity of the club, the mass of the club and the angle of the ball’s departure are essentially provided by the golfer upon striking. Since club head, club head mass, the angle of trajectory and environmental conditions are not determinants controllable by golf ball producers and the ball size and weight are set by the U.S.G.A., these are not factors of concern among golf ball manufacturers. The factors or determinants of interest with respect to improved distance are generally the coefficient of restitution (COR) and the surface configuration (dimple pattern, ratio of land area to dimple area, etc.) of the ball.

The COR in solid core balls is a function of the composition of the molded core and of the cover. The molded core and/or cover may be comprised of one or more layers such as in multi-layered balls. In balls containing a wound core (i.e., balls comprising a liquid or solid center, elastic windings, and a cover), the coefficient of restitution is a function of not only the composition of the center and cover, but also the composition and tension of the elastomeric windings. As in the solid core balls, the center and cover of a wound core ball may also consist of one or more layers.

The coefficient of restitution is the ratio of the outgoing velocity to the incoming velocity. In the examples of this application, the coefficient of restitution of a golf ball was measured by propelling a ball horizontally at a speed of 125+/-5 feet per second (fps) and corrected to 125 fps against a generally vertical, hard, flat steel plate and measuring the ball’s incoming and outgoing velocity electronically. Speeds were measured with a pair of Oehler Mark 55 ballistic screens available from Oehler Research, Inc., P.O. Box 9135, Austin, Tex. 78766, which provide a timing pulse when an object passes through them. The screens were separated by 36" and are located 25.25" and 61.25" from the rebound wall. The ball speed was measured by timing the pulses from screen 1 to screen 2 on the way into the rebound wall (as the average speed of the ball over 36"), and then the exit speed was timed from screen 2 to screen 1 over the same distance. The rebound wall was tilted 2 degrees from a vertical plane to allow the ball to rebound slightly downward in order to miss the edge of the cannon that fired it. The rebound wall is solid steel 2.0 inches thick.

As indicated above, the incoming speed should be 125±5 fps but corrected to 125 fps. The correlation between COR and forward or incoming speed has been studied and a

correction has been made over the ±5 fps range so that the COR is reported as if the ball had an incoming speed of exactly 125.0 fps.

The coefficient of restitution must be carefully controlled in all commercial golf balls if the ball is to be within the specifications regulated by the United States Golf Association (U.S.G.A.). As mentioned to some degree above, the U.S.G.A. standards indicate that a “regulation” ball cannot have an initial velocity exceeding 255 feet per second in an atmosphere of 75° F. when tested on a U.S.G.A. machine. Since the coefficient of restitution of a ball is related to the ball’s initial velocity, it is highly desirable to produce a ball having sufficiently high coefficient of restitution to closely approach the U.S.G.A. limit on initial velocity, while having an ample degree of softness (i.e., hardness) to produce enhanced playability (i.e., spin, etc.).

Coefficient of restitution (C.O.R.) was measured by firing the resulting golf ball in an air canon at a velocity of 125 feet per second against a steel plate positioned 12 feet from the muzzle of the canon. The rebound velocity was then measured. The rebound velocity was divided by the forward velocity to give a coefficient of restitution.

Shore D Hardness

As used herein, “Shore D hardness” of a cover layer is measured generally in accordance with ASTM D-2240, except the measurements are made on the curved surface of a molded cover layer, rather than on a plaque. Furthermore, the Shore D hardness of the cover layer is measured while the cover layer remains over the core and any underlying cover layers. When a hardness measurement is made on a dimpled cover, Shore D hardness is measured, to the best extent possible, at a land area of the dimpled cover.

Cut Resistance

Cut resistance was measured in accordance with the following procedure: A golf ball is fired at 135 feet per second against the leading edge of a pitching wedge wherein the leading edge radius is 1/32 inch, the loft angle is 51 degrees, the sole radius is 2.5 inches and the bounce angle is 7 degrees.

The cut resistance of the balls tested herein was evaluated on a scale of 1 to 5. The number 1 represents a cut that extends completely through the cover to the core. A 2 represents a cut that does not extend completely through the cover but that does break the surface. A 3 does not break the surface of the cover but does leave a permanent dent. A 4 leaves only a slight crease which is permanent but not as severe as 3. A 5 represents virtually no visible indentation or damage of any sort.

Spin Rate

The spin rate of the golf ball was measured by striking the resulting golf balls with a pitching wedge or 9 iron wherein the club head speed is about 105 feet per second and the ball is launched at an angle of 26 to 34 degrees with an initial velocity of about 110 to 115 feet per second. The spin rate was measured by observing the rotation of the ball in flight using stop action Strobe photography.

Initial Velocity

Initial velocity is the velocity of a ball when struck at a hammer speed of 143.8 feet per second in accordance with a test as prescribed by the U.S.G.A.

As will be noted, compositions A, B and C include high acid ionomeric resins, with composition B further including

zinc stearate. Composition D represents the inner layer (i.e. Surlyn 1605) used in U.S. Pat. No. 4,431,193. Composition E provides a hard, low acid ionomeric resin.

The purpose behind producing and testing the balls of Table 11 was to provide a subsequent comparison in properties with the multi-layer golf balls of the present invention.

TABLE 11

Molded Intermediate Golf Balls					
Ingredients of Inner Cover Compositions	A	B	C	D	E
Iotek 959	50	50	—	—	—
Iotek 960	50	50	—	—	—
Zinc Stearate	—	50	—	—	—
Surlyn 8162	—	—	75	—	—
Surlyn 8422	—	—	25	—	—
Surlyn 1605	—	—	—	100	—
Iotek 7030	—	—	—	—	50
Iotek 8000	—	—	—	—	50
Properties of Molded Intermediate Balls					
Compression	58	58	60	63	62
C.O.R.	.811	.810	.807	.793	.801
Shore C Hardness	98	98	97	96	96
Spin Rate (R.P.M.)	7,367	6,250	7,903	8,337	7,956
Cut Resistance	4-5	4-5	4-5	4-5	4-5

As shown in Table 11 above, the high acid ionomer resin inner cover layer (molded intermediate balls A–C) have lower spin rates and exhibit substantially higher resiliency characteristics than the low acid ionomer resin based inner cover layers of balls D and E.

Multi-layer balls in accordance with the present invention were then prepared. Specifically, the inner cover compositions used to produce intermediate golf balls from Table 11 were molded over the solid cores to a thickness of about 0.0375 inches, thus forming the inner layer. The diameter of the solid core with the inner layer measured about 1.620 inches. Alternatively, the intermediate golf balls of Table 11 were ground down using a centerless grinding machine to a size of 1.620 inches in diameter to produce an inner cover layer of 0.0375 inches.

The size of 1.620 inches was determined after attempting to mold the outer cover layer to various sizes (1.600", 1.610", 1.620", 1.630" and 1.640") of intermediate (core plus inner layer) balls. It was determined that 1.620" was about the largest “intermediate” ball (i.e., core plus inner layer) which could be easily molded over with the soft outer layer materials of choice. The goal herein was to use as thin an outer layer as necessary to achieve the desired playability characteristics while minimizing the cost of the more expensive outer materials. However, with a larger diameter final golf ball and/or if the cover is compression molded, a thinner cover becomes feasible.

With the above in mind, an outer cover layer composition was blended together in accordance with conventional blending techniques. The outer layer composition used for this portion of the example is a relatively soft cover composition such as those listed in U.S. Pat. No. 5,120,791. An example of such a soft cover composition is a 45% soft/55% hard low acid ionomer blend designated by the inventor as “TE-90”. The composition of TE-90 is set forth as follows:

Outer Cover Layer Composition TE-90	
Iotek 8000	22.7 weight %
Iotek 7030	22.7 weight %
Iotek 7520	45.0 weight %
White MB <sup>1</sup>	9.6 weight %

<sup>1</sup>White MB consists of about 23.77 weight percent TiO<sub>2</sub>; 0.22 weight percent Uvitex OB, 0.03 weight percent Santonox R, 0.05 weight percent Ultramarine blue and 75.85 weight percent Iotek 7030.

The above outer layer composition was molded around each of the 1.620 diameter intermediate balls comprising a core plus one of compositions A–D, respectively. In addition, for comparison purposes, Surlyn® 1855 (now Surlyn® 9020), the cover composition of the '193 patent, was molded about the inner layer of composition D (the intermediate ball representative of the '193 patent). The outer layer TE-90 was molded to a thickness of approximately 0.030 inches to produce a golf ball of approximately 1.680 inches in diameter. The resulting balls (a dozen balls for each example) were tested and the various properties thereof are set forth in Table 12 as follows:

TABLE 12

Finished Balls					
Ingredients:	1	2	3	4	5
Inner Cover Composition	A	B	C	D	D
Outer Cover Composition	TE-90	TE-90	TE-90	TE-90	Surlyn® 9020
Properties of Molded Finished Balls:					
Compression	63	63	69	70	61
C.O.R.	.784	.778	.780	.770	.757
Shore C Hardness	88	88	88	88	89
Spin (R.P.M.)	8,825	8,854	8,814	8,990	8,846
Cut Resistance	3–4	3–4	3–4	3–4	1–2

As it will be noted in finished balls 1–4, by creating a multi-layer cover utilizing the high acid ionomer resins in the inner cover layer and the hard/soft low acid ionomer resin in the outer cover layer, higher compression and increased spin rates are noted over the single layer covers of Table 11. In addition, both the C.O.R. and the Shore C hardness are reduced over the respective single layer covers of Table 11. This was once again particularly true with respect to the multi-layered balls containing the high acid ionomer resin in the inner layer (i.e. finished balls 1–5). In addition, with the exception of prior art ball 5 (i.e. the '193 patent), resistance to cutting remains good but is slightly decreased. As note above, the prior art ball of the '193 patent suffers substantially in durability (as well as in resiliency) in comparison to the balls of the present invention.

Furthermore, it is also noted that the use of the high acid ionomer resins as the inner cover material produces a substantial increase in the finished balls overall distance properties. In this regard, the high acid ionomer resin inner covers of balls 1–3 produce an increase of approximately 10 points in C.O.R. over the low acid ionomer resin inner covers of balls 4 and about a 25 point increase over the prior art balls 5. Since an increase in 3 to 6 points in C.O.R. results in an average increase of about 1 yard in distance, such an improvement is deemed to be significant.

Several other outer layer formulations were prepared and tested by molding them around the core and inner cover layer combination to form balls each having a diameter of about 1.68 inches. First, B. F. Goodrich Estane® X-4517 polyester polyurethane was molded about the core molded with inner layer cover formulation A. DuPont Surlyn®9020 was molded about the core which was already molded with inner layer D. Similar properties tests were conducted on these golf balls and the results are set forth in Table 13 below:

TABLE 13

Finished Balls		
Ingredients:	6	7
Inner Cover Layer Composition	A	D
Outer Cover Layer Composition	Estane® 4517	Surlyn® 9020
Properties of Molded Finished Balls:		
Compression	67	61
C.O.R.	.774	.757
Shore C Hardness	74	89
Spin (R.P.M.)	10,061	8,846
Cut Resistance	3–4	1–2

The ball comprising inner layer formulation D and Surlyn® 9020 identifies the ball in the Nesbitt U.S. Pat. No. 4,431,193 patent. As is noted, the example provides for relatively high softness and spin rate though it suffers from poor cut resistance and low C.O.R. This ball is unacceptable by today's standards.

As for the Estane® X4517 polyester polyurethane, a significant increase in spin rate over the TE-90 cover is noted along with an increased compression. However, the C.O.R. and Shore C values are reduced, while the cut resistance remains the same. Furthermore, both the Estane® X-4517 polyester polyurethane and the Surlyn® 9020 were relatively difficult to mold in such thin sections.

An additional embodiment according to the present invention utilizes blends of the Neo Cis polymers in the core compositions along with the hard, high acid mantle layers and relatively softer covers. The following Table represents core formulations which utilizes a blend of Neo Cis 40 and Neo Cis 60 with Cariflex BCP-820 (amounts of ingredients are in par per hundred rubber (phr) based on 100 parts butadiene rubber):

TABLE 14

Formulation No.				
Ingredient	1	2	3	4
Cariflex BCP-820	40	40	40	40
Neo Cis 60	30	30	30	30
Neo Cis 40	30	30	30	30
Zinc Oxide	31.4	30.9	26	24.6
Zinc Stearate	16	16	16	16
ZDA	18.2	19.2	18.2	19.6
Yellow MB	0.14	—	—	—
Green MB	0.05	—	—	—
Black MB	—	0.2	—	—
Red MB	—	—	0.075	0.075
Blue MB	—	—	0.075	0.075
Trignox 42-40B	1.25	1.25	1.25	1.25

The core formulations set forth above in Table 14 were then utilized to produce the following corresponding cores:

TABLE 15

Property	Core Sample			
	1	2	3	4
Size (pole dia. inches)	1.47" ± 0.004	1.47" ± 0.004	1.47" ± 0.004	1.47" ± 0.004
Weight (grams)	33.3 g ± 0.3	33.3 g ± 0.3	31.5 ± 0.3	31.5 ± 0.3
Riehle Comp.	135 ± 10	125 ± 10	145 ± 8	135 ± 8
C.O.R.	0.775 ± 0.015	0.765 ± 0.015	0.760 ± 0.015	0.770 ± 0.015
Specific Gravity	1.194 ± 0.05	1.194 ± 0.05	1.168	1.168
JIS C	69 ± 2	71 ± 2	70 ± 2	71 ± 2
Shore C	69 ± 2	71 ± 2	70 ± 2	71 ± 2
Shore D	40 ± 2	42 ± 2	41 ± 2	42 ± 2

In accordance with the present invention, the cores utilizing the blend of Neo Cis 40 and Neo Cis 60 have a relatively hard, high acid mantle or inner cover layer formed thereon. High acid ionomeric resins such as those designated as Surlyn®, manufactured by DuPont, and Iotek, manufactured by Exxon, are suitable for forming the inner cover layer. The following Table 16 includes ionomers which are exemplary of specific ionomers which may be utilized in an additional preferred embodiment of the inner cover layer of multi-layer balls according to the present invention. These examples are not intended to be limiting of the specific ionomers which can be used.

TABLE 16

	Individual Ionomers		
	Iotek 1002	Iotek 1003	Surlyn ® 8552
% Acid Type	18% AA	18% AA	19% MA
Ionomer Type	Copolymer	Copolymer	Copolymer
Cation	Na	Zn	Mg

The mantle layer may also contain other additives such as heavy weight fillers including bronze, brass, tungsten, and the like.  
The following represents various intermediate golf balls formed from the cores of Table 15.

TABLE 17

	Intermediate Ball with Inner Cover			
	1	2	3	4
Core Formulation (From Table 15)	1	2	3	4
Mantle Composition (wt %)				
Iotek 1002 (Na)	50%	50%	35%	35%
Iotek 1003 (Zn)	50%	50%	—	—
Surlyn 8552 (Ma)	—	—	65%	65%
Filler (Bronze Powder)	—	—	19.0 pph	19.0 pph
TiO <sub>2</sub>	—	—	0.1 pph	0.1 pph

The inner cover layers, or mantles, as set forth in Table 17 above have the following characteristics as shown in Table 18 below:

TABLE 18

Property	Intermediate Ball (from Table 17)			
	1	2	3	4
Flex Modulus (weighted avg.)	264 MPa	264 MPa	264 MPa	264 MPa
Stiffness Modulus	3521 Kgf/cm <sup>2</sup>	3521 Kgf/cm <sup>2</sup>	3521 Kgf/cm <sup>2</sup>	3521 Kgf/cm <sup>2</sup>
Size (intermediate ball)	1.570" ± 0.004	1.570" ± 0.004	1.570" ± 0.004	1.570" ± 0.004
Weight (intermediate ball)	38.3 g ± 0.3	38.3 g ± 0.3	38.3 g ± 0.3	38.3 g ± 0.3
Thickness	0.050" ± 0.008	0.050" ± 0.008	0.050" ± 0.008	0.050" ± 0.008
Riehle Comp	122 ± 12	112 ± 12	112 ± 12	106 ± 8
C.O.R.	0.780 ± 0.015	0.790 ± 0.015	0.790 ± 0.015	0.795 ± 0.015
Mantle Specific Gravity	0.96 ± 0.01	0.96 ± 0.01	1.12 ± 0.05	1.12 ± 0.05
JIS C	97 ± 1	97 ± 1	97 ± 1	97 ± 1
Shore C	97 ± 1	97 ± 1	97 ± 1	97 ± 1
Shore D	70 ± 1	70 ± 1	70 ± 1	70 ± 1

TABLE 16-continued

	Individual Ionomers		
	Iotek 1002	Iotek 1003	Surlyn ® 8552
Melt Index	2	1	1.3
Stiffness Modulus* <sup>2</sup>	4053 MPa	1873 MPa	3499 Kgf/cm <sup>2</sup>

AA = Acrylic Acid; MA = Methacrylic Acid  
\*<sup>2</sup>Stiffness measurements done using Toyoseiki Stiffness Tester

The intermediate balls, as shown in Table 17 were then formed into finished golf balls by covering them with a relatively softer outer cover formulation. The covers are typically ionomeric but other polymers may be utilized in the covers as set forth herein before. Ionomers typically associated with the golf balls according to the present invention include those designated as Surlyn®, manufactured by DuPont, and Iotek, manufactured by Exxon. The ionomers may be used individually or in blends. The following Table 19 includes ionomers which are exemplary of specific ionomers that may be utilized for the outer cover layer of golf balls according to the present invention.

TABLE 19

Outer Cover Ionomers									
	Surlyn 8940	Surlyn 9910	Surlyn 8320	Surlyn 8120	Surlyn 8549	Iotek 7030	Iotek 7510	Iotek 7520	Iotek 8000
% Acid Type	15% MA	15% MA	~7% MA	~7% MA	15% MA	15% AA	6% AA	6% AA	15% AA
Ionomer Type	Copolymer	Copolymer	Terpolymer	Terpolymer	Copolymer	Copolymer	Terpolymer	Terpolymer	Copolymer
Cation	Na	Zn	Na	Na	Na	Zn	Zn	Zn	Na
Melt Index	2.8	0.7	0.8	2	2.3	2.5	0.8	2	2
Stiffness Modulus* <sup>2</sup>	2705	2874	168	492	—	1840	284	270 MPa	3323
	Kgf/cm <sup>2</sup>	Kgf/cm <sup>2</sup>	Kgf/cm <sup>2</sup>	Kgf/cm <sup>2</sup>		Kgf/cm <sup>2</sup>	Kgf/cm <sup>2</sup>		Kgf/cm <sup>2</sup>

AA = Acrylic Acid; MA = Methacrylic Acid  
\*<sup>2</sup>Stiffness measurements done using Toyoseiki Stiffness Tester

The intermediate golf balls of Table 17 were then covered with cover formulations to produce the following finished golf balls:

TABLE 20

Finished Ball	A	B	C	D
Intermediate Ball (from Table 17)	1	2	3	4
Cover Composition (wt %)				
Surlyn 8549 (Na)	7.3%	7.3%	—	—
Iotek 7510 (Zn)	42%	42%	—	58.9%
Iotek 7520 (Zn)	50.7%	50.7%	—	—
Surlyn 8940 (Na)	—	—	17%	—
Surlyn 9910 (Zn)	—	—	50.1%	—
Surlyn 8320 (Na)	—	—	17.9%	—

TABLE 20-continued

Finished Ball	A	B	C	D
Surlyn 8120 (Na)	—	—	7.7%	—
Iotek 7030 (Zn)	—	—	7.3%	7.3%
Iotek 8000 (Na)	—	—	—	33.8%
Whitener (TiO <sub>2</sub> )*	2.3 phr	2.3 phr	2.3 phr	2.3 phr

\*Amount based on parts per hundred resin

The finished balls of Table 20 above had the following characteristics:

TABLE 21

Finished Ball (from Table 20)				
Property	A	B	C	D
Flex Modulus (weighted avg.)	58 MPa	58 MPa	240 MPa	140 MPa
Stiffness Modulus (estimate)	~300 Kgf/cm <sup>2</sup>	~300 Kgf/cm <sup>2</sup>	1820 Kgf/cm <sup>2</sup>	763 Kgf/cm <sup>2</sup>
Combined Mantle/Cover Stiffness	~700 Kgf/cm <sup>2</sup>	~700 Kgf/cm <sup>2</sup>	1942 Kgf/cm <sup>2</sup>	—
Cover Specific Gravity	0.98 ± 0.01	0.98 ± 0.01	0.98 ± 0.01	0.98 ± 0.01
Size	1.685" ± 0.005	1.685" ± 0.005	1.685" ± 0.005	1.685" ± 0.005
Weight	45.4 g ± 0.4	45.4 g ± 0.4	45.4 g ± 0.4	45.4 g ± 0.4
Riehle Compression	105 ± 10	100 ± 10	95 ± 5	85 ± 5
C.O.R.	0.770 ± 0.015	0.780 ± 0.015	0.790 ± 0.015	0.790 ± 0.015
JIS C	72 ± 1	72 ± 1	93 ± 1	87 ± 1
Shore C	72 ± 1	72 ± 1	93 ± 1	87 ± 1
Shore D	46 ± 1	46 ± 1	62 ± 1	56 ± 1

An additional step of exposure to gamma radiation was performed on balls A and B of Table 21 producing golf balls having the following characteristics:

TABLE 22

Finished Balls (Post Gamma)				
Finished Ball (From Table 21)	A (Ball)	A (Core)	B (Ball)	B (Core)
Property (Post Gamma)				
Gamma Dosage (Ball)	35–70 Kgys	—	35–70 Kgys	—
Size	1.683" ± 0.003	1.47" ± 0.004	1.683" ± 0.003	1.47 ± 0.004
Thickness (Cover)	0.057" ± 0.008	—	0.057" ± 0.008	—
Weight	45.5 g ± 0.4	33.3 g ± 0.3	45.5 g ± 0.4	33.3 g ± 0.3
Riehle Compression	86 ± 5	120 ± 10	81 ± 5	110 ± 10
C.O.R.	0.795 ± 0.015	0.770 ± 0.020	0.800 ± 0.015	0.780 ± 0.020
Cover Specific Gravity	0.98 ± 0.01	—	0.98 ± 0.1	—
Core Specific Gravity	—	1.194 ± 0.05	—	1.194 ± 0.05
JIS C	72 ± 1	78 ± 2	72 ± 1	80 ± 2

TABLE 22-continued

Finished Ball (From Table 21)	Finished Balls (Post Gamma)			
	A (Ball)	A (Core)	B (Ball)	B (Core)
Shore C	72 ± 1	78 ± 2	72 ± 1	80 ± 2
Shore D	46 ± 1	48 ± 2	46 ± 1	50 ± 2
Dimple Pattern	422 Tri	—	422 Tri	—

The method of gamma radiation treatment of golf balls, including benefits and property changes attained therefrom, is taught in commonly assigned U.S. Pat. No. 5,857,925 to Sullivan et al., which is incorporated herein by reference. Benefits and/or property changes associated with gamma radiation treatment of golf balls include, but are not limited to, increased melting temperature for the ionomer cover, increased compression and C.O.R. for the core, allows softer starting materials for core, etc.

The invention has been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

What is claimed is:

- 1. A golf ball comprising a core and a cover for covering said core;  
said core comprising (i) a first polybutadiene rubber obtained utilizing a cobalt catalyst and having a Mooney viscosity in the range of from about 70 to about 83, and (ii) a blend of polybutadiene rubbers wherein each is obtained by utilizing a lanthanide series catalyst and having a Mooney viscosity of from about 30 to about 70; and,  
said cover comprising an inner layer cover and an outer layer cover, said inner cover layer being formed from a relatively hard, ionomeric resin or blend of ionomeric resins having an acid content of at least 16%, and said outer cover being relatively softer than said inner cover.
- 2. The golf ball according to claim 1 wherein said inner cover layer has a stiffness modulus of from about 3000 Kgf/cm<sup>2</sup> to about 5,500 Kgf/cm<sup>2</sup>.
- 3. The golf ball according to claim 1 wherein in said core said first polybutadiene rubber includes at least 90% cis-1,4 polybutadiene.
- 4. The golf ball of claim 1 wherein said blend of polybutadiene rubbers comprises a first polybutadiene having a Mooney viscosity of about 40 and a second polybutadiene having a Mooney viscosity of about 60.
- 5. The golf ball of claim 4 wherein said blend of polybutadiene rubbers is comprised of about 30% by weight of a first polybutadiene having a Mooney viscosity of about 40 and about 30% by weight of a second polybutadiene having a Mooney viscosity of about 60, based on the total weight of said first polybutadiene and said blend of polybutadiene rubbers.
- 6. The golf ball according to claim 1, wherein said base resin of said inner cover layer comprises a blend of ionomer resins.
- 7. The golf ball of claim 6 wherein said blend comprises a blend of a sodium neutralized ionomer resin and a zinc neutralized ionomer resin.
- 8. The golf ball of claim 6 wherein said blend comprises a blend of a sodium neutralized ionomer resin and a magnesium neutralized ionomer resin.

- 9. The golf ball of claim 1 wherein the inner cover layer further includes a heavy weight filler.
- 10. The golf ball of claim 9 wherein the heavy weight filler is a bronze powder.
- 11. The golf ball according to claim 1 wherein said inner cover layer has a Shore D hardness of at least about 70.
- 12. A golf ball comprising a core and a cover for covering said core;  
said core comprising (i) a first polybutadiene rubber obtained utilizing a cobalt catalyst and having a Mooney viscosity in the range of from about 70 to about 83, and (ii) a blend of polybutadiene rubbers wherein each is obtained by utilizing a lanthanide series catalyst and having a Mooney viscosity of from about 30 to about 70; and,  
said cover comprising an inner layer cover and an outer layer cover, said inner cover layer being formed from a relatively hard, ionomeric resin or blend of ionomeric resins having an acid content of at least 16%, and said outer cover being relatively softer than said inner cover,  
wherein said inner cover layer has# Shore D hardness of at least about 70.
- 13. The golf ball according to claim 12 wherein said inner cover layer has a stiffness modulus of from about 3,000 Kgf/cm<sup>2</sup> to about 5,500 Kgf/cm<sup>2</sup>.
- 14. The golf ball according to claim 12 wherein in said core said first polybutadiene rubber includes at least 90% cis-1,4 polybutadiene.
- 15. The golf ball of claim 12 wherein said blend of polybutadiene rubbers comprises a first polybutadiene having a Mooney viscosity of about 40 and a second polybutadiene having a Mooney viscosity of about 60.
- 16. The golf ball of claim 15 wherein said blend of polybutadiene rubbers is comprised of about 30% by weight of a first polybutadiene having a Mooney viscosity of about 40 and about 30% by weight of a second polybutadiene having a Mooney viscosity of about 60, based on the total weight of said first polybutadiene and said blend of polybutadiene rubbers.
- 17. The golf ball according to claim 12, wherein said base resin inner cover layer comprises a blend of ionomer resins.
- 18. The golf ball of claim 17 wherein said blend comprises a blend of a sodium neutralized ionomer resin and a zinc neutralized ionomer resin.
- 19. The golf ball of claim 17 wherein said blend comprises a blend of a sodium neutralized ionomer resin and a magnesium neutralized ionomer resin.
- 20. The golf ball of claim 12 wherein the inner cover layer further includes a heavy weight filler.
- 21. The golf ball of claim 20 wherein the heavy weight filler is a bronze powder.

\* \* \* \* \*